


AN ABSTRACT OF THE THESIS OF  
Irene Osterman-Sussman for the degree of Master of Arts in  
Interdisciplinary Studies in the co-departments of Fisheries  
and Wildlife, Zoology, and Museum Studies presented on  
August 2, 1993.

Title: Informal Education on an Estuary Nature Trail: A  
Study of Visitor Knowledge, Attitudes and Behavior.

Abstract approved:  Redacted for Privacy  
Dr. Lavern Weber

The Mark O. Hatfield Marine Science Center (HMSC) public education opportunities include interpretive programs offered along the Estuary Nature Trail. The purpose of this study was to determine the effectiveness of three informal education programs, interpretive signs, a self-guided trail brochure, and guided naturalist walks, in imparting information on the ecology of estuaries to visitors. A second objective was to determine visitors attitudes towards estuarine and wetland conservation issues.

A questionnaire including knowledge and attitude statements and demographics was distributed to 901 participants. Results show that the three programs are effective in teaching visitors about estuarine ecology, with the naturalist walks being the most effective. Knowledge of estuarine ecology and attitudes towards estuarine and

wetland conservation issues were associated with visitor characteristics such as level of education, membership in a conservation organization, residence proximity to wetlands, awareness of local wetland controversies, and previous visits to an estuary trail.

Observations of visitor behavior along the estuary trail showed that visitor groups spent an average of 16 minutes on the trail. At each interpretive sign between 54 and 77% of the visitors were observed reading the information; those reading times ranged from 16 to 33 seconds per sign.

Informal Education on an Estuary Nature Trail:  
A Study of Visitor Knowledge, Attitudes,  
and Behavior.

by

Irene Osterman-Sussman

A THESIS

submitted to

Oregon State University

in partial fulfillment  
of the requirements for the  
degree of

Master of Arts in Interdisciplinary Studies

Completed August 2, 1993

Commencement June 1994

APPROVED:

Redacted for Privacy

\_\_\_\_\_  
Professor of Fisheries and Wildlife in charge of major

Redacted for Privacy

\_\_\_\_\_  
Professor of Zoology in charge of co-field

Redacted for Privacy

\_\_\_\_\_  
Professor of Anthropology in charge of co-field

Redacted for Privacy

\_\_\_\_\_  
Chairman of department of Fisheries and Wildlife

Redacted for Privacy

\_\_\_\_\_  
Dean of Graduate School

Date thesis is presented August 2, 1993

Dedicated to Adam and Brenna  
and the memory of Mary-Michele

## ACKNOWLEDGEMENTS

I would like to gratefully acknowledge the Katherine Bisbee Fund of the Oregon Community Foundation for their interest and financial contribution to this project. I would like to thank the HMSC volunteer staff who helped administer the surveys; Elizabeth Asbury, Peg Bickford, Jay and Fran DeMott, Lew and Margaret Emmons, Debra Falk, Nicola Hines, Mary Emma Parks, Lorraine Shewbert, and Joe and Mary Voelkel. I would like to acknowledge the HMSC volunteer naturalists, Helen and Walter Bronson, Nancy Crocker, Judy Deakin, Carol Franklin, and Len and Fonte Gassner.

I would like to thank each of my committee members at Oregon State University, Larry Burrill, Dan Edge, Roberta Hall, and Mark Hixon for their support, encouragement, and advice throughout the duration of the study. I am especially grateful to my major professor Lavern Weber, for his interest, time and patience, for the countless drafts he poured over, and for his belief in the importance of successfully educating the public. That belief has been a source of inspiration to me throughout this project.

I would like to thank my parents, Paul and Alice Osterman, for instilling in me the value of education. Finally, I especially wish to thank my husband, Adam Sussman, for his help with survey administration, computer advice, countless hours of discussions, and for his encouragement and support through every phase of the study.

## TABLE OF CONTENTS

|  |     |
|--|-----|
| INTRODUCTION . . . . .   | 1   |
| Scientific Literacy and Informal Learning Centers. . .   | .1  |
| Informal Education. . . . .  | 3   |
| Study Objectives . . . . .   | .8  |
| REVIEW OF LITERATURE. . . . .  | .10 |
| Research Methods . . . . .   | 10  |
| Results of Learning Studies . . . . .  | .12 |
| Factors Affecting Learning in Informal Settings . . .  | 13  |
| Results of Attitude Studies . . . . .  | 17  |
| The Relationship Between Knowledge and Attitude . . .  | .19 |
| Multiple Program Analysis . . . . .  | .19 |
| DESCRIPTION OF THE STUDY . . . . .   | .21 |
| The Trail . . . . .  | .21 |
| Study Questionnaire and Sampling Site . . . . .  | .22 |
| Estuary Trail Education Programs and Treatment<br>Groups . . . . .                               | 24  |
| Sampling Methods . . . . .   | 25  |
| Recording, Scoring and Analyzing the Surveys . . . .   | 30  |
| Visitor Behavior . . . . .   | 35  |
| RESULTS . . . . .  | 38  |
| Knowledge Scores . . . . .   | 38  |
| Total Knowledge Scores by Demographics . . . . .   | 41  |
| Attitude Scores by Study Group . . . . .   | 48  |
| Total Knowledge Score by Attitude Score . . . . .  | .48 |
| Attitude Scores by Demographics . . . . .  | .50 |
| Study Group Demographics . . . . .   | 53  |
| Visitor Behavior . . . . .   | 55  |
| DISCUSSION . . . . .   | .60 |
| Visitors Knowledge of Estuarine Ecology . . . . .  | .60 |
| Relative Effectiveness of the Three Education<br>Programs . . . . .                              | 63  |
| Demographic Characteristics and Knowledge Scores . .   | 70  |
| Visitors Attitudes Towards Conservation Issues . . .   | 73  |
| Demographic Characteristics and Visitors Attitudes .   | 76  |
| CONCLUSION. . . . .  | 78  |
| FUTURE RECOMMENDATIONS . . . . .   | .82 |
| REFERENCES CITED . . . . .   | .87 |
| APPENDICES . . . . .   | .94 |
| Appendix I      Hatfield Marine Science Center Estuary<br>Trail Education Study Questionnaire. . | .94 |

## TABLE OF CONTENTS CONTINUED

|              |  |     |
|--------------|--|-----|
| Appendix II  | Hatfield Marine Science Center<br>Estuary Trail Brochure . . . . .   | 98  |
| Appendix III | Hatfield Marine Science Center<br>Estuary Trail: A Manual for<br>Naturalists . . . . .   | 107 |
| Appendix IV  | Degree Categories of College Graduate<br>Majors and Post Graduate Areas of<br>Study, of Participants in the Estuary<br>Trail Education Study . . . . . | 147 |
| Appendix V   | Demographics and Visitor<br>Characteristics of Participants in<br>the Estuary Trail Education Study .  | 153 |
| Appendix VI  | Visitor Population on the Hatfield<br>Marine Science Center Estuary Trail  | 156 |
| Appendix VII | Hatfield Marine Science Center<br>Estuary Trail Brochure II . . . . .  | 157 |



## LIST OF FIGURES

| Figure |   | Page |
|--------|---|------|
| 1.     | Mean Total Knowledge Score of participants in the HMSC estuary trail education programs by study group . . . . .                              | 39   |
| 2.     | Mean Group Knowledge Scores for participants in the HMSC estuary trail education programs as compared to a control group . . . . .            | 40   |
| 3.     | Group Knowledge Scores by percent correct for participants in the HMSC estuary trail education programs compared to a control group . . . . . | 42   |
| 4.     | Mean Total Knowledge Score by level of education for participants in the HMSC estuary trail informal education study . . . . .                | 44   |
| 5.     | Mean Total Knowledge Score by Attitude Score of participants in the HMSC estuary trail informal education study . . . . .                     | 49   |
| 6.     | Mean Attitude Scores by level of education of participants in the HMSC estuary trail informal education study. . . . .                        | 51   |

## LIST OF TABLES

| Table   | Page |
|---|------|
| 1. Mean Total Knowledge Score by Age Group of Participants in the Estuary Trail Education Study . . . . .   | 43   |
| 2. Increase in Total Knowledge Score Between the Control and Treatment Groups in the Estuary Trail Education Study, by Level of Education . . . . . | 45   |
| 3. Mean Total Knowledge Score by Degree of Participants in the Estuary Trail Education Study . . . . .  | 45   |
| 4. Increase in Total Knowledge Score Between the Control and Treatment Groups in the Estuary Trail Education Study, by Degree. . . . .              | 46   |
| 5. Mean Total Knowledge Score by Number of People Under the Age of Fifteen in the Participants Party . . . . .                                      | 48   |
| 6. Mean Attitude Score by College Degree of Participants in the Estuary Trail Education Study . . . . .   | 52   |
| 7. Mean Attitude Score by Residence Proximity to Wetlands of Participants in the Estuary Trail Education Study. . . . .                             | 52   |
| 8. Visitor Use of the HMSC Estuary Trail During the Education Study, by Month . . . . .   | 56   |
| 9. Distance Travelled Along the HMSC Estuary Trail by Observed Parties . . . . .  | 57   |
| 10. Parties Observed Going to the Beach During Their Walk on the HMSC Estuary Trail . . . . .   | 58   |
| 11. Visitor Observations at Interpretive Signs along the HMSC Estuary trail . . . . .   | 58   |
| 12. Amount of Time Visitors Observed Reading Interpretive Signs Along the HMSC Estuary Trail. .   | 69   |
| 13. Minimum Reading Time Requirement for the Interpretive Signs Along the HMSC Estuary Trail. .   | 69   |

## LIST OF APPENDIX TABLES

### Appendix IV

| Table  | Page |
|--|------|
| IV.1.      Majors and Areas of Study in the Degree<br>Category Natural Science . . . . . | 147  |
| IV.2.      Majors and Areas of study in the Degree<br>Category Other Science . . . . .   | 148  |
| IV.3.      Majors and Areas of Study in the Degree<br>Category Engineering . . . . .     | 149  |
| IV.4.      Majors and Ares of Study in the Degree<br>Category Education . . . . .        | 149  |
| IV.5.      Majors and Areas of Study in the Degree<br>Category Liberal Arts . . . . .    | 150  |
| IV.6.      Majors and Areas of Study in the Degree<br>Category Business . . . . .        | 151  |
| IV.7.      Majors and Areas of Study in the Degree<br>Category Technical/Other . . . . . | 152  |

### Appendix V

| Table   |     |
|---|-----|
| V.1.      Percent of Males and Females in Study Groups  | 153 |
| V.2.      Percent of Study Group Participants in Age<br>Categories . . . . .  | 153 |
| V.3.      Percent of Study Group Participants in<br>Education Levels . . . . .  | 154 |
| V.4.      Percent of Study Group Participants in<br>College Degree Categories . . . . .   | 154 |
| V.5.      Percent of Study Group Participants Living<br>Within Ten Miles of a Wetland or Not . . . . .                                  | 155 |
| V.6.      Percent of Study Group Participants in<br>Categories of Number of People in Their<br>Party . . . . .                          | 155 |
| V.7.      Percent of Study Group Participants in<br>Categories of Number of People Under the Age<br>of Fifteen in Their Party . . . . . | 155 |

INFORMAL EDUCATION ON AN ESTUARY NATURE  
TRAIL: A STUDY OF VISITOR KNOWLEDGE,  
ATTITUDES, AND BEHAVIOR.

INTRODUCTION

Scientific Literacy and Informal Learning Centers

The ultimate fate of the environment rests in decisions that are made through the political process. At the federal, state and local levels, regulations and legislation determine whether habitats are preserved or altered to match perceived human needs. Ultimately, the public makes these decisions, either through their ability to vote on initiatives, or through the representatives they elect. In either case, the fate of the environment rests in the hands of the general public.

To make educated decisions, people must be informed. Because many issues surrounding the quality of the environment are intertwined with science and technology, it has become increasingly important that people are literate in these disciplines. Citizens need a basic understanding of science and, ideally, an awareness of science-related issues, so they can make informed political decisions on environmental and scientifically based issues (Shen 1975, Lucas 1983, Massey 1988).

Shen (1975) describes the ideal understanding as civic

scientific literacy; a literacy that enables citizens to make sound decisions regarding conservation of habitats, including wetlands. A scientific literacy study conducted in 1985 concluded that only 5% of Americans were functionally literate (Miller 1988). The cost of illiteracy is a populace unable to comprehend the issues. People who do not understand scientific issues cannot participate meaningfully in decisions regarding science, technology and the environment (Massey 1988).

Shen (1975) points out that one way to increase civic scientific literacy is to expose people to science. Because the science classes that people take in school generally cannot provide them with all of the background they will need to understand a changing world, there must be additional opportunities for to learn science (Miller 1988).

While the avenues that Shen (1975) proposes for increasing scientific literacy include TV and radio programs, there are many facilities that provide out-of-school or informal educational programs in science. Informal learning centers include museums, science centers, aquariums, zoos, nature preserves, and federal, state and local parks and forest areas. The contribution these facilities make towards increasing scientific literacy rests on the effectiveness of their programs in imparting knowledge to their visitors, and instilling confidence in visitors' ability to understand scientific information.

increasing scientific literacy. There is the excitement of discovery, the confidence in ones ability to understand the world, and the potential of stimulating interest in and curiosity about scientific processes. These are important opportunities at informal education centers.

In 1989 there were 8,200 museums, including science centers, aquariums and zoos, in the United States that together received more than half a billion visits (AAM 1989). In 1983 it was estimated that approximately 160 million people in the United States visited science centers, zoos, aquaria, science museums and nature centers annually. This was more visitors than all professional sporting events combined (Koran et al 1983). The estimate of visitors to nature parks and preserves was even higher. Thus, science learning centers have a great opportunity to extend the world of science to a large number of people.

### Informal Education

Education in informal settings is very different from formal academic programs. One difference is the education mode. While academic teaching generally involves a lecture delivered in a classroom, informal programs can take many forms. Exhibits, brochures, guided walks and videos are some of the programs that may be called informal education or interpretation.

Along with diverse program types, informal education involves diverse participants. Museum audiences (and other program participants) are comprised of people of all ages, races, nationalities, and social classes, with diverse interests, skills and knowledge. While some have extensive understanding of science, the environment, or any other subject to be taught, others have little or no formal experience in the field (Falk et al. 1986, Screven 1986). This heterogeneity means that educational programs must be developed to meet the diverse needs of their audience, while enabling the facility to achieve its educational goals.

Visitors to museums and nature trails are leisure-oriented; they are on their free time and voluntarily participate in the educational opportunities. They have come to a non-structured learning environment and whether or not they pay attention or become involved is their decision. The visitors set their own goals and any learning that takes place is self-paced, self-directed and non-linear (Falk et al. 1986, Screven 1986). Falk (1982) equated museum visitors with shoppers in a department store; while some are serious and move quickly through the facility with a predetermined plan of what they will see, others will browse, stopping here and there at an exhibit that attracts their attention. While this second group will try to see as much of the museum as they can, they may spend extra time at an exhibit they find especially interesting. Thus the

educators must design exhibits and other programs that will attract visitors attention and stimulate their interest.

Motivation to become involved in a program, either by reading, listening to a presentation, or interacting with an exhibit, varies greatly among visitors to informal education facilities (Falk et al. 1986). Motivation is related to personal factors such as interest, background, and the amount of time the individual has to spend at an activity. Beyond the personal factors, what motivates visitors to learn is different from formal programs where extrinsic rewards such as grades, money or the possibility of a job encourage participation. In informal programs the motivation for learning is intrinsic; there is something about the activity that is so intriguing that the individual focuses attention on it. Curiosity, exploration, fantasy, and social interaction are some of the intrinsic rewards for learning in an informal setting (Czikszentmihalyi 1988, Screven 1988, Wittlin 1968).

For the vast majority of visitors, the educational experience must be enjoyable. Rosenfeld (1980) found two thirds of the reasons given by family groups for coming to the San Francisco Zoo were unrelated to the zoo's educational goals and included activities such as watching people, walking in a safe place, and having a good time. Two studies at the British Museum of Natural History found that 74 to 79% of visitors surveyed upon entering the museum



reported their expectations for the visit were to acquire some knowledge, have their interest stimulated, and enjoy themselves (Alt 1980, Griggs and Alt 1982). Screven (1986) noted that in these settings, learning must be fun; visitors must derive enjoyment out of the activity or they will not become involved.

Social interaction within visitor groups is another important part of the visit to museum and nature trail settings and is among the major attractions of the facilities (Screven 1986, McManus 1987). Rosenfeld (1980) found social interaction takes up a large portion of the visitors' time. McManus (1987) points out the importance of social interaction among visitor groups; even while participating in an educational program, the social needs of visitors will come first. Consequently, the challenge to educators is to link the educational goals of the facility with the social and recreational interests of the visitors (Screven 1986). Much of the learning that occurs can be socially mediated, one group member reading exhibit text to the rest of the party for example (Laetsch et al. 1980, Falk et al. 1986, Screven 1986).

Museum and nature trail visitors also bring very different understandings and beliefs with them to their visit. Visitors may have preconceived ideas about a topic, ideas that may either be incorrect or over-simplifications of the subject. These "naive notions" can affect the

visitors' interpretation of the program (Borun 1990, Screven 1988). When visitors' preconceptions are not compatible with the information that is presented, they generally will cling to their prior beliefs unless the program is specifically designed to change those preconceptions (Baron and Hogan 1988). To effectively educate, informal learning center staff must determine any misunderstandings visitors have about the subject and design the program to address those preconceptions.

While the term naive notions refers to an individual's understanding of a topic, visitors may also have personal attitudes toward the subject of an interpretive program, particularly if the subject revolves around an environmental issue. A visitor's attitude toward an issue represents both the information an individual has about that issue, and their positive or negative evaluation of that information. Educational programs therefore, have the potential of affecting visitors' attitudes towards a subject or an issue by adding to the information they have on that subject or issue (Kiely-Brocato 1980, Sakoffs 1984). Programs, for example, that increase an individual's understanding of a habitat, and the value of that habitat to fish, wildlife and humans, may affect their attitudes towards conservation issues surrounding the use of that habitat.

The educational programs offered through informal learning facilities have the potential of attracting a large

audience. The heterogeneity of this audience presents unique challenges to educators. However, successful programs have the potential of stimulating interest in science, increasing scientific literacy, and instilling confidence in the ability of participants to comprehend scientific issues, including issues surrounding the environment. Educational programs may also affect the attitudes visitors have about science related topics including environmental issues.

### Study Objectives

Because of the great educational potential of informal learning centers, it seems appropriate that research be conducted to determine the most effective methods of teaching program participants. To add to the body of knowledge on informal education, I conducted a study of visitors to the Hatfield Marine Science Center (HMSC) estuary trail. The objectives of the study were to answer the following questions:

- 1) Does exposure to the HMSC educational programs affect visitors knowledge of estuarine ecology?
- 2) Are all three educational programs conducted on the HMSC estuary trail, (interpretive signs, self-guided trail brochure and naturalist-led walks), effective in transmitting information on estuarine ecology to visitors? Which program is the most effective?

- 3) Does exposure to HMSC interpretive programs affect visitors attitudes toward estuarine and wetland conservation issues?
- 4) Does knowledge of estuarine ecology correlate with a conservation-oriented attitude towards estuaries and wetlands?
- 5) Does knowledge of estuarine ecology and attitudes towards estuarine conservation issues vary with demographics and other visitor characteristics?

## REVIEW OF LITERATURE

The realization among informal educators of the potential their programs have in reaching visitors has encouraged research and evaluation in many facilities. Museums have taken the lead in this work, and while this study was conducted in an outdoor setting, much of the museum research is applicable to the methods and findings of this study.

### Research Methods

Research methods for assessing informal educational programs vary. A number of studies on the effects of school field trips to science museums and nature centers have used pre- and posttests. In this design, students take a test, participate in the program, and then take the same test (Falk and Balling 1982, Stronck 1983, Wright 1980). Many studies with adult visitors to informal facilities have also used pre- and posttests (DeWaard et al. 1974, Fortner and Lyon 1984, Kellert and Dunlap 1989).

There are some difficulties with using pre- and posttests. The pretest itself can become part of the visitor's experience, making it difficult to judge the effect of the program in the absence of the pretest. In addition, people may act differently, for example, they may pay more attention to the program, if they know they are

going to be questioned later (Lucas 1983, Webb et al. 1966). To control for these effects, some researchers have used a modified pre- and posttest design by having one group of participants take the test without program exposure (control), and a different group take the test after program exposure (DeWaard et al. 1974, Olson et al. 1984, Borun 1977, Borun and Miller 1979). Tests used by researchers to measure knowledge and attitude (Borun 1977, Fortner and Teates 1980, Fortner and Lyon 1984, Westphal and Halverson 1985), often follow the format designed by Maloney and Ward (1973). The test they constructed included multiple choice knowledge questions and scaled attitude questions (Maloney and Ward 1973, Maloney et al. 1975).

Behavioral observations are another method of gathering data on visitors. A number of researchers have followed visitors and measured the length of time they stand in front of an exhibit and/or read the text (Borun 1977, Borun and Miller 1979, Tissot 1991). In a study designed to assess learning at a science center, DeMouthe (1989) tracked visitors unobtrusively and recorded their conversations. A study conducted at the Lawrence Hall of Science included a questionnaire before and after the visit, detailed observations on randomly selected individuals, and interviews with individuals after the visit (Gottfried 1979). Other researchers have combined knowledge tests with behavioral observations (Falk and Balling 1982, Peart 1984).

### Results of Learning Studies

Much of the work with visitors to informal educational facilities has focused on what visitors know about a subject, and whether or not exposure to a program affects that knowledge. While the majority of the work has been with school children visiting museums, researchers have evaluated the learning potential of indoor and outdoor programs both with school groups and general visitors. Wright (1980) measured comprehension of human health in two groups of 6th graders; one visited a museum for a hands-on experience, the other had a classroom review. He found the group that participated in the museum review had superior comprehension compared to the classroom group. Eason and Linn (1975) found students who viewed an optics exhibit showed significant knowledge gains of the presented information. Other studies on student groups also found significant knowledge gains after participation in an informal educational program (Falk and Balling 1982, Stronck 1983).

Studies of adults have also found knowledge gains in visitors after participating in an educational program. Some examples include the work by Borun (1977) and Borun and Miller (1979) on the effectiveness of museum labels at the Franklin Institute of Science. In both studies the authors concluded that participants who viewed an exhibit and read the labels had higher knowledge scores than those who saw

the exhibit but had no text to read. Fronville and Doering (1989) assessed the effectiveness of a rainforest exhibition in communicating facts and issues. They concluded that the exhibition effectively imparted information. Hammitt (1984) found significant knowledge gains in day-hikers who visited an interpretive trail. And Fortner and Lyon (1984) reported a large increase in knowledge scores in viewers who watched a Television documentary.

#### Factors Affecting Learning in Informal Settings

While numerous investigators have established that learning does occur with exposure to informal education, the amount of knowledge gained varies between participants and programs. A variety of factors regarding the visitor, the program, and the facility, may influence the amount of learning that takes place. Some researchers have concentrated their studies on establishing the characteristics that affect informal education learning.

In order for learning to occur, the first criterion is that a visitor must pay attention to the program. Borun and Miller (1979) found that while visitors read only 18% of the labels in the facility, they read an average of 68% of the label text at displays where they stopped. These results led them to suggest that if a display can attract and hold a visitor's attention, it is likely the visitor will read the label associated with that display. In the same study,



museum labels of varying lengths were tested to determine what length is most effective as measured by knowledge scores. The authors found that as the number of topics and lines of text increased, the percent of visitors who read the entire label decreased. They concluded that if the goal is to reach a majority of potential label-reading visitors, approximately 21 to 30 lines of text on two to three topics is the most effective (Borun and Miller 1979).

Although there is no agreement on the amount of time a visitor must be involved for learning to occur, the amount of time and attention given to an exhibit by a visitor does appear to have a direct bearing on the educational effectiveness of that display (Falk 1983, Lucas 1983, Screven 1976). Falk (1983) determined that a combination of time spent and visitor behavior at the exhibit are good predictors of learning. In his study, visitors who spent a relatively long time at an exhibit displaying positive learning behaviors showed significant knowledge gains. Shettel et al. (1968) concluded that the amount of viewing time and the motivation level of the participant both influence the knowledge gained.

Some researchers have noted a difference in learning between casual and serious visitors. Shettel et al. (1968) concluded that their control group scored as well or higher than the casual visitor, a finding that led them to suggest that unless the casual visitor has background knowledge or

has specific learning intents, it is likely that little learning will result from casual visits to exhibits. Other studies, (Parsons 1968, DeWaard et al. 1974, Screven 1975, Kellert and Dunlap 1989) with reports of short times spent at exhibits and few labels read, suggest that casual visitors at museums, zoos and other informal learning centers learn little.

Along with exhibit attraction and holding power, and visitor motivation, other characteristics have been found to affect learning in informal settings. At the British Columbia Provincial Museum, Stronck (1983) found that learning was higher in students who participated in a structured docent-led tour than in the group who participated in an unstructured teacher-led tour. His results suggest that in a naturalist or interpreter-led program, the presenter may have as much of an effect on learning as the visitors themselves.

Falk and Balling (1982) compared student behavior and learning on field trips to a schoolyard and a nature center. They found that while younger students were more focused and learned more from the lesson in the schoolyard, older students had higher knowledge gains from the activity at the nature center. The authors proposed that setting novelty can affect learning. Younger students learn most in a setting that is not too novel, while older ones do better in a more novel setting. Similar to the older students, adults

will attend to exhibits or programs that are moderately novel, or unique, or form unexpected configurations. Exhibits that are less novel may attract adults if they appear out of context, have an emotional association, or are familiar due to media exposure (Screven 1986).

The Survey of Oceanic Attitudes and Knowledge (SOAK) test was designed to indicate the levels of marine awareness among 10th graders in Virginia (Fortner and Teates 1980). The results showed that coastal inhabitants had significantly higher scores than those living inland. The results also indicated that experiences such as viewing Cousteau programs on television, reading "National Geographic" magazine, and swimming ability were positively related to high levels of marine awareness. In a similar study focusing on aquatic topics, Fortner and Mayer (1983) found nearshore residence correlated with high levels of aquatic awareness.

Fronville and Doering (1989) in a study of a rainforest exhibition found that visitors who were exposed to the subject through the news media before their visit were less likely to grasp the basic message of the exhibition than those who were not. The effect of the media was to dilute the message of the exhibition.

### Results of Attitude Studies

The goals of a majority of informal education programs generally include an increased awareness and understanding of the subject to be taught. Additional program goals may focus on participants beliefs, opinions, and attitudes regarding the facility or the topic of a program. Increasingly, researchers are studying visitors attitudes, including attitudes towards science and conservation, and whether exposure to informal education programs has a measurable effect on those attitudes.

Roggenbuck and Passineau (1986) found that elementary students developed more positive attitudes about protecting park resources and visiting parks after visiting Indiana Dunes National Lakeshore . Cable et al. (1987) found positive attitudes about forestry and forest management in visitors who had been to Ontario National Forest. And, Olson et al. (1984) found increases in visitor attitudes towards preserve management concepts after exposure to an educational program.

The results of Fortner and Lyon's (1984) study of the attitude effects of a Cousteau documentary indicated that the treatment group shifted towards the program goals after viewing the program. However, they conducted a two-week retention test that indicated a slight shift back to pre-program levels.

Borun's (1977) study at the Franklin Institute of Science found that visitor attitudes towards science and scientists were lower after their visit than before. She attributed these results to the construction that was being conducted at the facility during her study.

Research on the effects of long-term programs has met with mixed results. While Sheppard and Speelman (1986) found that participation in outdoor education programs at a 4-H camp appeared to have little effect upon environmental attitudes, George (1967) concluded that each of three programs, a 4-H conservation camp, a college conservation course and an adult conservation workshop, all resulted in significant increases in positive conservation attitudes. Millward (1975) also found more positive attitudes after a resident camp experience.

Kiely-Brocato (1980) evaluated visitor attitudes towards resource management. She first asked participants to identify actions they believed to be park policy, then what their attitudes were towards those actions. The results indicated that while overall attitudes toward resource management were fairly positive, some negative visitor attitudes were attributed to non-existent park policies. She concluded that an educational program can potentially do more harm than good if prior visitor attitudes are not considered.

### The Relationship Between Knowledge and Attitude

There has been some research into the question of whether knowledge of a subject correlates with a positive attitude towards that subject. Fortner and Teates (1980) found a strong correlation between knowledge of the ocean and positive attitudes towards aquatic conservation in 10th grade students. In a study of high school students from seven schools, Cohen (1973) found a positive relationship between environmental knowledge and environmental attitudes. He also found that the group with higher environmental knowledge was more willing to express their attitude, responding with "strongly agree" or "strongly disagree", while the low knowledge group responded more often with "no comment". Other studies have shown a strong correlation between environmental knowledge and positive environmental attitudes among students (Richmond 1976, Hounshell and Liggett 1973). In a study of adults visiting preserves in Ohio, Olson et al. (1984) found a positive relationship between scores on a knowledge test and scores on an attitude test for preserve management concepts.

### Multiple Program Analysis

Relatively few studies have simultaneously compared the effectiveness of different program types on visitors knowledge and attitude. Mahaffey (1969) conducted a study along a 9-stop self-guided history walk designed so visitors

would be exposed three times to each of three media: a recorder, signs, and a leaflet. His results showed that slightly more correct information was retained from messages given by the recorder, the signs were second, and the leaflet was the least effective.

Olson et al. (1984) investigated the effectiveness of three programs in improving visitor knowledge and attitudes towards nature preserve management. Participants hiked a trail with one of three media available: signs, a brochure, or park personnel. The authors found that visitor knowledge and attitudes increased most when using the brochure or personal services, and least with the signs. Other researchers (Nielsen and Buchanan 1986, Dowell and McCool 1986), found comparable results for increases in knowledge scores with brochures, booklets, slide programs and naturalist-led walks.

## DESCRIPTION OF THE STUDY

I used several data collection methods for this project including a questionnaire, visitor observations, visitor counts, publication of an estuary brochure, and development of a naturalist training program and an associated training manual. The study was conducted during four seasons: summer, 24 August through 8 September 1991; fall, 28 September through 27 October; winter, 28 December 1991 through 23 February 1992; and spring, 22 March through 10 May. Visitor surveys and observations were conducted between 0900 and 1700h.

The study was conducted every day of the week throughout the summer season, and from 28 December to 5 January and 21 March to 29 March to coincide with winter and spring holidays. During all other periods data was collected on Friday, Saturday, and Sunday. There were occasions when the study was canceled either for the entire day or a period of the day due to adverse weather conditions or personal factors such as a last-minute cancellation by a volunteer researcher.

### The Trail

The HMSC estuary trail begins at the southeast end of the Center's public parking lot and winds 0.4 miles along the estuary in a southwest direction. The trail ends at a saltmarsh west of the main complex of HMSC buildings; visitors return along the same route. The trail was constructed in



1988; it is paved, wheelchair accessible, and has two shelters and three benches for visitor use. The trail winds through a terrestrial habitat consisting largely of introduced grasses and shrubs interspersed with some native vegetation for the majority of the route. Because most of the vegetation is low-growing, the estuary is visible from nearly all points along the trail. At low tide visitors can see the tideflats extending across the estuary. While the trail was designed with one access point to the beach and tideflats, (at the first shelter), several paths have been worn to the beach along the first half of the trail.

#### Study Questionnaire and Sampling Site

Questionnaire: The questionnaire (Appendix I) consisted of three sections: 1) Knowledge of estuarine ecology, 2) Attitudes towards estuarine conservation issues, and 3) Demographics.

The knowledge of estuarine ecology section included 24 statements on the ecology of estuaries with True, False, or Not Sure options for each statement. The attitude towards estuarine conservation issues section included 12 statements, each focusing on an estuarine or wetland conservation issues. Response options in this section were: 1) Strongly Agree, 2) Agree, 3) Neither Agree nor Disagree, 4) Disagree, 5) Strongly Disagree.

The final portion of the survey included 10 demographic questions such as age, sex, education, etc. One of the questions asked participants how many people under the age of fifteen were in the respondent's party. Age fifteen was subjectively chosen based on the belief that in a nature trail setting, people fifteen and older require less of their parents' time and effort than those under fifteen. The purpose of the question was to determine if parents focusing on their children show significantly different knowledge scores than individuals not in the company of children.

Sampling Site: The questionnaires were administered approximately 20 m from the start of the trail. I chose this site for a number of reasons:

1. The site is out of view of the parking lot; if the site were at the beginning of the trail visitors could be distracted by the proximity of their vehicles and may be more inclined to refuse to fill out the questionnaire.

2. There is a large, stable log adjacent to the trail for survey participants to sit on while filling out the questionnaires.

3. From that point survey administrators could observe visitors almost to the fourth sign to determine that survey participants had walked at least that far.

4. I could monitor the activity of new visitors entering the trail in between administering questionnaires.

### Estuary Trail Educational Programs and Treatment Groups

There were three educational programs available on the HMSC estuary trail: signs, brochures and guided naturalist walks. Nine fiberglass imbedded signs interpreting the natural or human history of the estuary and the adjacent uplands, are in place along the trail. I designed a self-guided trail brochure interpreting the ecology of the estuary and the adjacent uplands (Appendix II). The brochure had nine designated stops corresponding to the placement of the nine interpretive signs. The signs were covered when the brochures were being tested.

I designed a training program for volunteer staff at the HMSC to guide walks along the estuary trail. All naturalists attended a six week training course, three hours a week, taught by HMSC staff on the ecology of the estuary and the adjacent uplands, and interpretation techniques. All naturalists received a training manual (Appendix III).

The questionnaires were administered to four designated sets of visitors to the HMSC estuary trail.

1. Control Group -- Visitors who had just entered the estuary trail and had not been exposed to an HMSC estuary trail education programs.
2. Sign Group -- Visitors returning along the estuary trail while the interpretive signs were available.
3. Brochure Group -- Visitors returning along the trail who had the self-guided trail brochure.

4. Naturalist Group -- Visitors who participated in a guided walk led by a trained HMSC volunteer estuary naturalist.

The experiment was designed so that visitors did not have access to more than one interpretive media. Brochures were not available during the control, sign and naturalist group study periods and the signs were covered during the brochure group study period.

Because of the placement of the station, control group participants did see signs 1 and 2. Sign 1 is the subject of question 1 of the survey. Because all visitors were exposed to that information, all surveys theoretically receive one extra point. Sign 2 contained no information included in the questionnaire.

The only group that had access to more than one interpretive media was the naturalist group. The signs were uncovered during the naturalist walks. I was unable to determine whether naturalist participants read the signs.

#### Sampling Methods

Group Sampling: The study was conducted in two-hour time periods each day: period 1, 0900-1100h; period 2, 1100-1300h; period 3, 1300-1500h; and period 4, 1500-1700h.

Sampling times for the control, sign, and brochure groups were determined by a combination of random and systematic sampling. The naturalist group was not included in this

sampling method because naturalist walks are part of the HMSC summer educational programs and are scheduled each day at 1100h. During fall, winter and spring, naturalist walks were offered at either 1100h or 1300h on days when volunteer naturalists were available.

The sampling order for the remaining three groups was randomly drawn at the beginning, control-brochure-sign, and maintained throughout the study. Each season the treatment group sampled during period 1 on the first day was randomly determined. For summer the starting group was control.

Throughout the study groups were systematically placed into the two-hour time slots in the given order of control-brochure-sign. Because the starting group for the summer was control, the schedule for day 1 of the summer was: control, 0900-1100h; brochure, 1100-1300h; sign, 1300-1500h; control, 1500-1700h. Day 2 began with brochure, then sign, control, brochure. Day 3 was sign, control, brochure, sign and day 4 began the sequence with control, brochure, sign, control.

In the fall, winter and spring seasons the randomly chosen starting group for day one was sign for each season. For each of those seasons, the first day's schedule was: sign 900-1100h, control 1100-1300h, brochure 1300-1500h, sign 1500-1700h; day 2 began with control, day 3 brochure and on day 4 the sequence began again with sign.

To assure that participants in the control, sign and brochure groups did not encounter a naturalist, if one of

those groups were scheduled during a naturalist walk, sampling was postponed until the walk was over and administrators were sure participants would not encounter a naturalist.

If the brochure group were scheduled during the naturalist walk, the covers were not put over the signs and the brochures were not put into the rack until all naturalist participants had completed their walk. Occasionally the naturalist walk lasted over an hour. If the brochure group were scheduled during that time it was canceled due to the time needed to cover the signs.

If the control group were scheduled during the naturalist walk the administrator would wait until the naturalist group walked past the survey site before sampling the control group.

For this project there are several advantages to a combination of random and systematic sampling.

1) Randomness is built into the study; sampling group order and beginning group for each season were randomly determined.

2) From 0900-1100h and 1600-1700h there were generally few visitors along the trail, the systematic design allowed for one group to be studied during both of those time periods on the same day to increase the sample size, and assured that all groups would be rotated through these times.

3) Because the naturalist group potentially interfered with the 1100-1300h, or 1300-1500h groups each day, the systematic approach assured that each group rotated through

this slot. Additionally, since this time slot tended to have the highest visitor population on the trail, if there were no guided walk on a day, the systematic design assured that each group had the same chance of being scheduled during these high use times.

4) The approach of using two-hour time slots assured that each group would be studied every day. Due to factors such as weather, day of the week, and local events, the number of visitors on the trail in one day varied from a low of 2 to a high of 406 during the study. A sampling design based solely on random drawings of groups would not assure a representative cross-section of estuary trail visitors for each of the study groups.

Study Participants: The study was limited to participants who: 1) were age 18 or older; 2) walked by the station on the trail, not on the beach; and 3) could read the questionnaire and circle the answers on their own, without any verbal assistance from the researcher. The reason for the third requirement was that an unconscious bias towards a statement may be revealed in a researcher's voice which can influence the participants response. Self-administered surveys control for this influence (Weisberg and Bowen 1977).

During a study period, all visitors walking by the station who fit the requirements of the project and of the group being sampled were asked if they would participate. The

exception to sampling all visitors occurred when a male-female pair approached the station; here administrators randomly selected a participant by flipping a coin. Random selection determined that heads would be male and tails would be female.

If a group walked by the survey site, all adults were requested to fill out the questionnaire, again with the exception of the random selection of male-female pairs. The only occasions when an administrator may not have approached a visitor were: 1) when the administrator was in the middle of explaining the study to another visitor, or, 2) when there were many participants at one time and all clipboards were being used.

Controlling for Administrator and Participant Bias: Potential human bias that could be evident in the methods include: 1) administrator's bias in choosing participants; 2) participants learning of the study which could influence their behavior on the trail; and 3) naturalists focusing their talks on information contained in the questionnaire.

To control for the first potential bias, all volunteers who administered surveys participated in a two hour training session. During this session the goals and objectives of the project were explained and the importance of correct sampling procedures was stressed. Throughout the training, volunteers were instructed to approach every visitor who appeared to meet the study criteria.



Studies have indicated that visitors who know a study is in progress may pay more attention to the available interpretation than those who do not (Lucas 1983, Webb et al. 1966). At all times I attempted to control for participants having prior knowledge of the study. Volunteer administrators were instructed not to tell any visitors walking down the trail that a study was being conducted. If a participant indicated in any way, such as by a comment, that he/she knew that this type of study were being conducted, the volunteer was instructed not to survey that individual. Volunteer naturalists were also instructed not to tell their visitors that a study was being conducted.

All naturalists who led walks during the project participated in a training program. To control for the naturalists focusing their walks on information contained in the questionnaire, the questionnaire was kept from the naturalist staff until the end of the project. Volunteer administrators were requested not to reveal any survey questions to the naturalists.

#### Recording, Scoring, and Analyzing the Surveys

All surveys were recorded into a computer database, Reflex, version 2.0 (Reflex, Database, Management, Graphics and Analysis, Borland International Inc. 1989).

Total Knowledge Scores: Total knowledge was calculated from the first section of all surveys by adding the correct

answers. Those scores were computed for each questionnaire and each received a Total Knowledge Score. The maximum total knowledge score possible was 24. Eight participants did not answer three or more questions from the knowledge section; those surveys were deleted in the knowledge score analysis.

Group Knowledge Scores: All participants in this study were asked to fill out the same questionnaire with the same 24 knowledge questions. Each question reflected information available in at least one of the education programs (the signs, brochure or naturalist walk). However, because the information available in each program was not identical, e.g. all information contained in the brochures was not duplicated in the signs or on the naturalist walk, all knowledge statements on the questionnaire did not pertain to all treatments. The questionnaire contained 13 questions from the signs, 17 from the brochure, and 14 from the estuary naturalist program. Group Knowledge Scores were computed from those three sets of questions such that each survey received a total knowledge score as well as a brochure, sign, and naturalist knowledge score.

Attitude towards conservation issues: For the attitude section, the response to each statement was first scaled and then entered into the database. Responses I defined to be the most conservation oriented were given a 5, the least conservation oriented received a 1, 4 and 2 represented the mid-range and 3 was held at "neither agree nor disagree". The

maximum attitude score possible was 60. Fifty participants did not respond to one or more attitude statements. Those surveys were deleted in the attitude score analysis.

Demographics: Answers in this section were recorded in numerical values exactly as the participant had responded.

In response to the question, "What is the level of education you have completed?" only two participants circled "grade school" and only nineteen circled "some high school". Those surveys were not included in the analysis due to the low sample size.

Three demographic questions required a text response, major in college, area of study in graduate school, and environmental concern. These were recorded as they were written and later transcribed to a numerical value. The responses for major in college and area of study were combined for analysis into one category called degree. Those responses were grouped into the following degree categories: natural science, other science, engineering, education, liberal arts, business, and technical/other (Appendix IV). If the degree category for a participant differed between undergraduate and post graduate work, the latter was chosen for this analysis. This occurred 12 times.

In response to the question, "How many people are in your group today?", all surveys with numbers greater than seven were combined for analysis into one category of seven and above due to a low sample size of responses in the higher

numbers. For the question, "How many (people) are under the age of fifteen?", all surveys with numbers greater than three were combined for analysis into one category of three and above for the same reason.

Survey Analysis: The survey results were analyzed with the statistical software program Statgraphics, version 5.0 (Statistical Graphics System, Statistical Graphics Corporation. 1989).

One-way Analysis of Variance (ANOVA) was used to determine whether the difference in mean total knowledge scores of the treatment groups as a whole was significantly different from the control, and to determine whether the difference in mean total knowledge scores of the four study groups was significant. ANOVA was also used to determine whether the mean total knowledge scores of participants within demographic groups (i.e. age categories) were significantly different from each other. A Tukey test was used to determine which means differed from which.

Analysis of covariance (ANCOVA) was used to determine whether the difference in scores between participants who had been on the HMSC estuary trail previously, and who had been on another trail previously, were significant and whether those differences could be attributed to participation in one of the study groups. ANCOVA was performed on these characteristics because analysis determined that participants in the study

groups were not evenly distributed in these two categories.

I used ANOVA to compare the Group Knowledge Scores of participants in each of the sign, brochure and naturalist groups with the scores received by participants in the control group. For example, the mean sign score received by the sign group was compared by ANOVA to the mean sign score received by the control group. The same comparison to the control group results was made for the brochure and naturalist groups with their group scores.

The mean Group Knowledge Scores for each of the three treatment groups were calculated and a mean percent correct was assigned to each group.

Similar to the knowledge score analysis, attitude scores within demographic groups were analyzed by ANOVA. I also used ANOVA to determine whether the mean attitude scores of the study groups were significantly different.

The ANOVA and ANCOVA test assumptions of normally distributed populations with equal variation were investigated by multiple box plots and scatterplots of the residuals versus their predicted values. Cochrans C test and Bartlett's test were used to determine homogeneity of variance.

Total mean knowledge scores and mean attitude scores were initially compared with a scatterplot and then by Linear Regression analysis to determine if a correlation between knowledge and attitude was apparent.

### Visitor Behavior

Visitor Counts: On October 12, 1991, an automatic counter was installed at the beginning of the trail. The number was recorded each morning and evening of the study. A count of trail visitors by week was collected from October 12, 1991 through May 31, 1993.

Visitor Observations: Visitor observations were conducted to determine the behavior of visitors on the HMSC estuary trail. I conducted all observations to assure uniformity.

Observation Sites: Three sites were used to collect data on visitor behavior. All observations were conducted from a distance of between 4 and 20 m. The site for the first set of observations was located on top of the large water storage facility immediately adjacent to the trail. From here I could observe visitors as they entered the trail until they left the fourth sign.

Once the visitor left sign 4, I would move to the next observation site; a field west of the Environmental Protection Agency building at the Center. From here, signs 5 and 6 could be observed. Due to its placement amongst many trees and shrubs, at no time could sign 7 be observed unobtrusively.

Once visitors left sign 6, I would move north approximately 20 m. to a spot where signs 8 and 9, as well as the end of the trail could be observed.

Observation Participants and Data: Visitor behavior participants were chosen systematically; the first visitor group to enter the trail who appeared to have at least one member over the age of 18 was observed. If a group included more than one adult, I observed the first person who began reading the sign. If the person I was observing discontinued reading the signs, I recorded a time of 0 at each sign and began to record the times for another adult member of the group. If no individual read the signs, I continued to observe the group and recorded a time of 0 at each sign.

For each visitor group followed, I first recorded trail entrance time and group composition. Then, using binoculars and a stopwatch I recorded the time the visitor appeared to be reading the interpretive signs. I determined a visitor was reading the sign if his/her head was bent towards the sign. Once the visitor looked away from the sign the watch was stopped. In cases where a visitor would momentarily look up and then continue reading a total time per sign was recorded.

Along with reading times, I also recorded the distance visitors along the trail, and whether they went to the beach from the trail. The time visitors reached the end of the trail, and the time they reentered the trail and headed towards the beginning were also recorded.

I observed an individual or a group the entire length of the trail, or until one of the following occurred: 1) the visitor sat on a bench or went into a shelter and remained for

over 5 minutes, 2) the visitor took a path to the beach and remained on the beach for over 5 minutes, 3) the visitor took a path to the beach and headed down the beach out of sight. Visitors were not observed on their walk back to the beginning of the trail due to the length of time required for conducting one set of observations.

I attempted to record brochure reading times. However, a few observations showed that unless I could see the brochure, there was no way to determine that the visitor was actually reading it. Because the visitors were usually facing away from me towards the estuary, accurate observations of the brochure group were not possible.

Observation Times: During summer observations were conducted in two-hour blocks of time. Since the brochure was not completed until the fall season, the observation period took the place of the brochure period for the summer. This method was advantageous in that it ensured that the study group rotation would be the same for all four seasons, and it gave me two-hour blocks of time to conduct observations.

During fall, observations were conducted haphazardly; when volunteer administrators were available which freed me to do observations. No observations were conducted during control group periods to control for a possible change in behavior in visitors who had been surveyed. For winter and spring, weather and lack of volunteer administrators precluded me from conducting observations.



## RESULTS

A total of 901 participants filled out questionnaires; 246 in the summer, 269 in fall, 163 in winter, and 223 in spring.

### Knowledge Scores

Total Knowledge Scores: The mean total knowledge score for the control group was 12.0 ( $SE \pm 0.24$ ,  $n=263$ ), and was lower than the mean total knowledge score for the treatment groups combined ( $\bar{X}=14.8$   $SE \pm 0.15$ ,  $n=629$ ) ( $F=94.578$ ,  $df=1,891$ ,  $P < 0.001$ ).

The mean total knowledge score received by the control group was lower than the score received by all other groups, and the mean score received by the sign group was also lower than the score of the brochure and naturalist groups ( $F=43.664$ ,  $df=3,891$ ,  $P < 0.001$ ) (Figure 1).

Group Knowledge Scores: The mean sign score for the sign group was 8.2 ( $n=327$ ) which was higher than the mean sign score for the control group ( $\bar{X}=6.8$ ,  $n=263$ ) ( $F=24.643$ ,  $df=3,893$ ,  $P < 0.001$ ) (Figure 2). The brochure group averaged 10.9 ( $SE \pm 0.22$ ,  $n=177$ ) out of 17 for the brochure score, which was higher than the control group average of 8.3 ( $SE \pm 0.18$ ,  $n=263$ ) ( $F=38.218$ ,  $df=3,893$ ,  $P < 0.001$ ). The naturalist participants scored 10.2 ( $SE \pm 0.22$ ,  $n=125$ ) out of 14, a higher score than received by the control group which was 7.2 ( $SE \pm 0.15$ ,  $n=263$ ) ( $F=46.284$ ,  $df=3,893$ ,  $P < 0.001$ ).

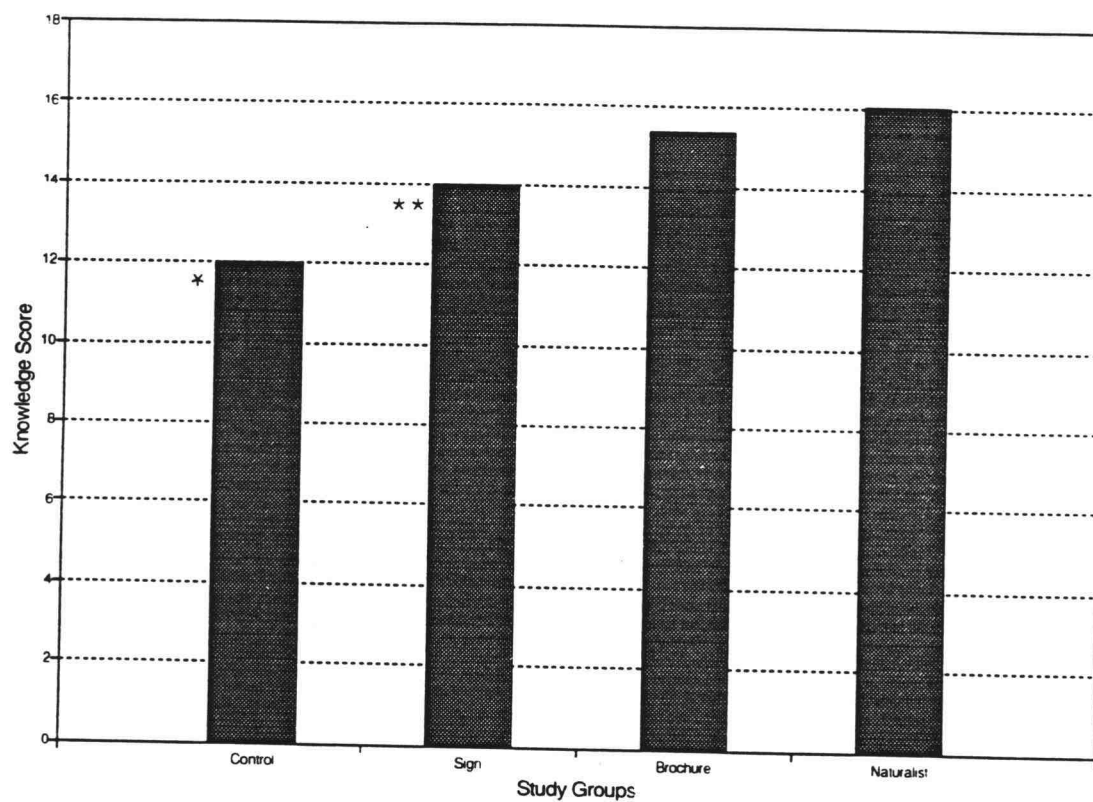


Figure 1: Mean Total Knowledge Score of participants in the HMSC estuary trail education programs by study group.

\*Score lower than all other groups.

\*\* Score lower than Brochure and Naturalist groups.  
( $P < 0.001$ )

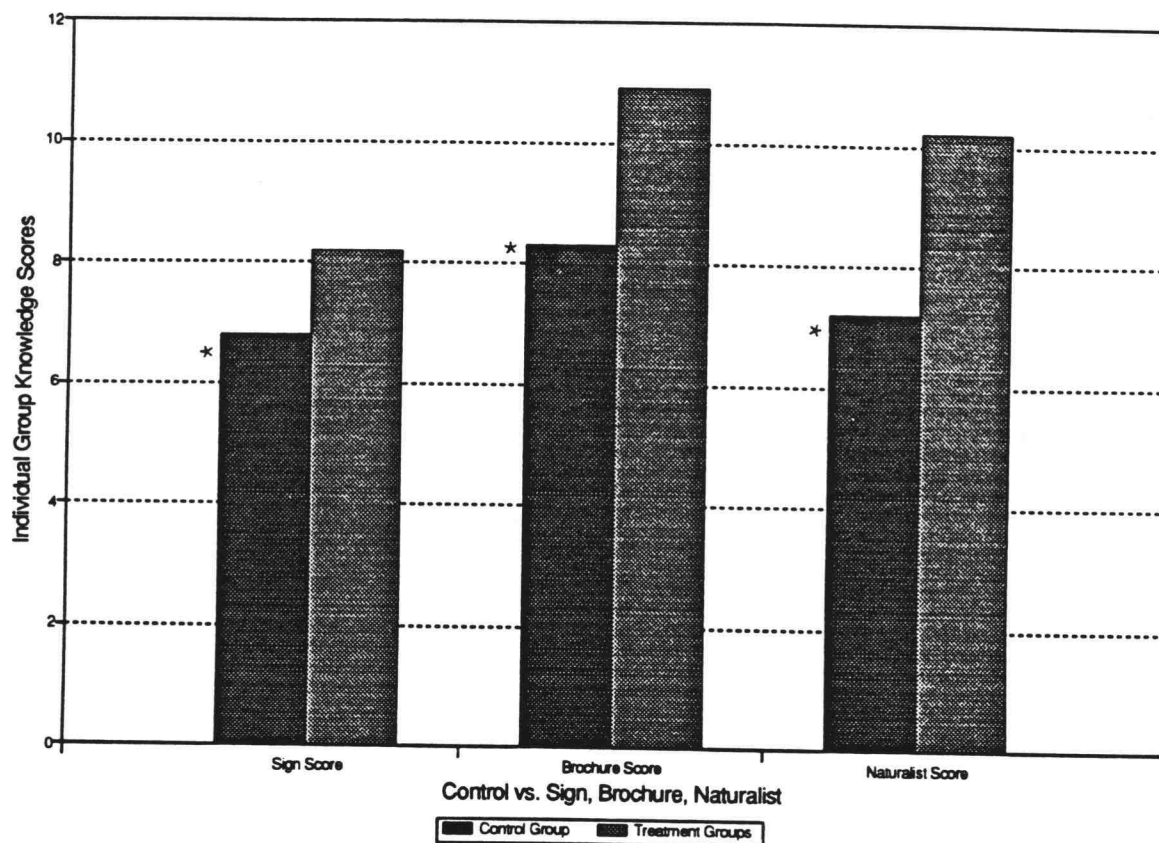


Figure 2: Mean Group Knowledge scores for participants in HMSC estuary trail education programs as compared to a control group.

\*Control group score lower than treatment groups ( $P < 0.001$ ).

The Group Knowledge Scores cannot be compared among one another statistically because they represent different sets of questions on the survey. However, the results can be evaluated by the percent increase each treatment group's score represented when compared to the control. The sign group's score was 11% higher than the score received by the control group. The brochure group's score was 15% higher than the control group's score. And, the naturalist group's score represented a 22% increase over the score received by the control group (Figure 3).

#### Total Knowledge Scores by Demographics

Total knowledge scores differed by demographic and other visitor characteristics. Mean total knowledge score for females ( $\bar{X}=13.6$ ,  $SE\pm 0.19$ ,  $n=464$ ) was lower than the score for males ( $\bar{X}=14.6$ ,  $SE\pm 0.20$ ,  $n=390$ ) ( $F=13.865$ ,  $df=1,852$ ,  $P=0.0002$ ).

Participants in the lower two age groups, (18-27 and 28-37) had the same mean knowledge score, and participants in the upper two age groups (58-67 and 68+) had the same mean score (Table 1). The score received by participants in age group 38-47 was significantly higher than the score of the lower two age groups ( $F=4.111$ ,  $df=5,881$   $P=0.0011$ ).

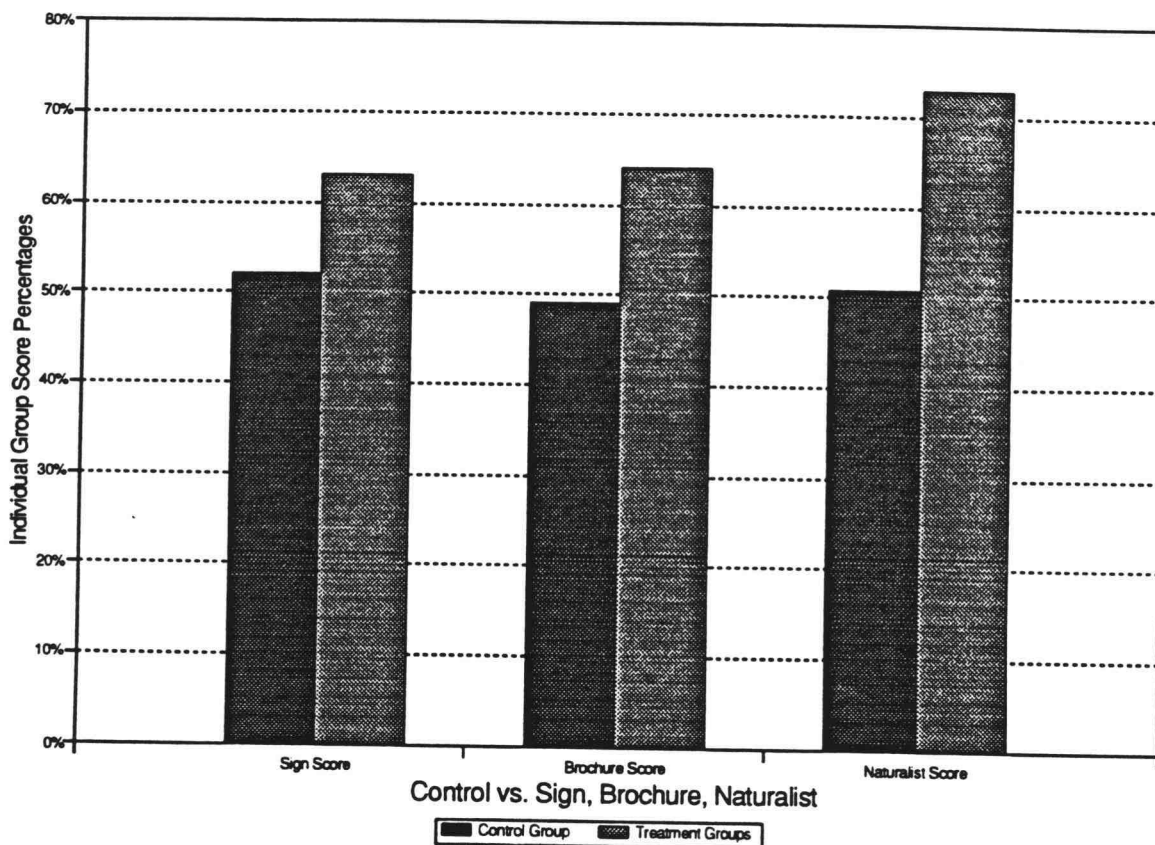


Figure 3: Group Knowledge Scores by percent correct for participants in the HMSC estuary trail education programs compared to the control group.

| Table 1 - Mean Total Knowledge Score by Age Group of Participants in the Estuary Trail Education Study. |                      |            |
|---|----------------------|------------|
| Age Group   | Mean Knowledge Score | SE         |
| 18-27 (n=107)   | 13.2a*               | $\pm 0.39$ |
| 28-37 (n=200)   | 13.2a                | $\pm 0.29$ |
| 38-47 (n=276)   | 14.7b                | $\pm 0.24$ |
| 48-57 (n=139)   | 14.1ab               | $\pm 0.34$ |
| 58-67 (n=114)   | 14.2ab               | $\pm 0.38$ |
| 68+ (n=51)  | 14.2ab               | $\pm 0.57$ |

Maximum total knowledge score = 24.

\*Means followed by the same letter are not statistically different from one another ( $P < 0.01$ ).

Total mean knowledge scores increased with increasing level of education (Figure 4). High school graduates had lower scores than individuals in each level above that category and individuals with some college had lower scores than college graduates and those with post graduate education ( $F=21.511$ ,  $df=3,862$ ,  $P < 0.001$ ). The total knowledge scores for the control group was compared to the treatment groups as a whole for each level of education. Knowledge scores for all education levels increased approximately 3 points over the control (Table 2).

Mean total knowledge scores varied with each college degree category (Table 3). Significant differences were seen only between the natural science degree holders and each of the other groups ( $F=4.378$ ,  $df=6,418$ ,  $P=0.0003$ ).

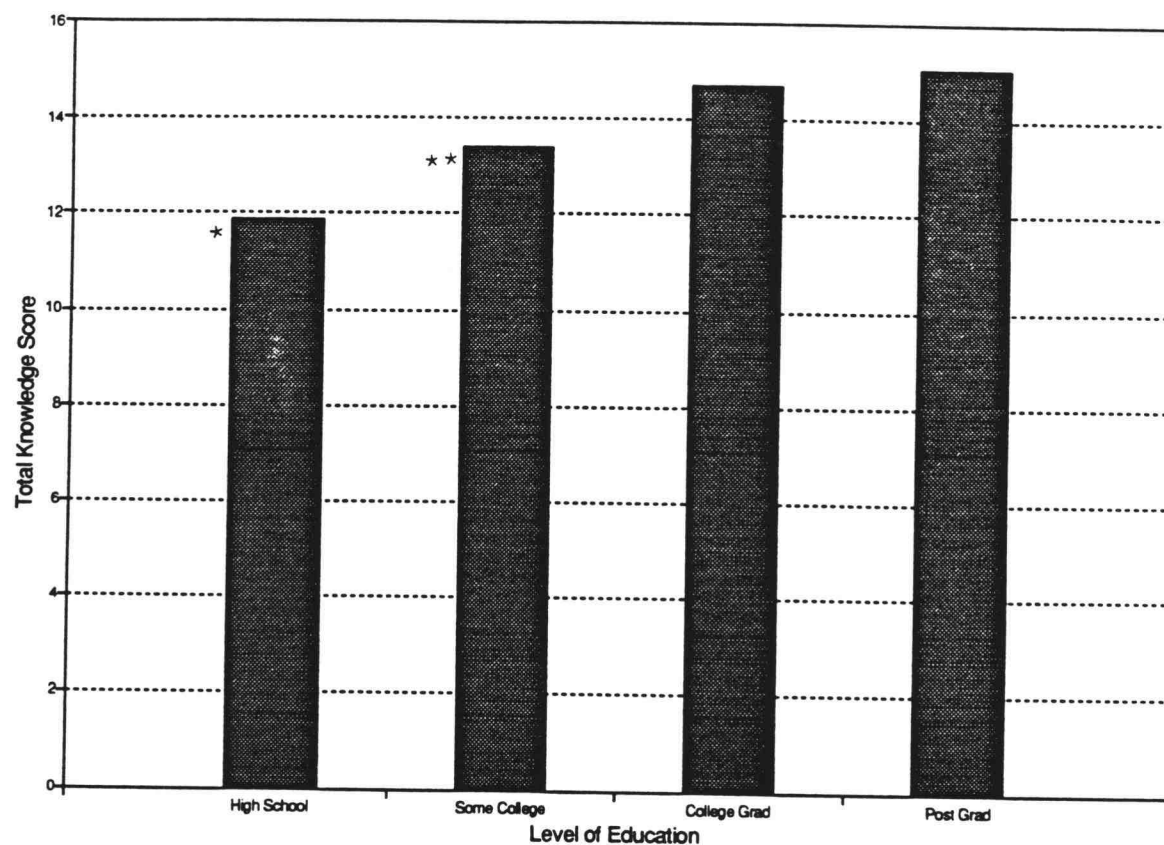


Figure 4: Mean Total Knowledge Score by level of education for participants in HMSC estuary trail informal education study.

\*Score lower than all other groups.

\*\*Score lower than college graduates and post graduates.  
( $P < 0.001$ )

| Table 2 - Increase in Total Knowledge Score<br>Between the Control and Treatment Groups in the<br>Estuary Trail Education Study, by Level of Education. |   |
|---|---|
| Level of Education  | Mean Increase in<br>Total Knowledge Score |
| High School   | +2.9                                      |
| Some College  | +2.6                                      |
| College Graduate  | +2.8                                      |
| Post Graduate   | +2.9                                      |

| Table 3 - Mean Total Knowledge Score by College Degree of<br>Participants in the Estuary Trail Education Study. |                          |            |
|---|--------------------------|------------|
| Degree  | Total Knowledge<br>Score | SE         |
| Technical/other (n=22)  | 13.9a                    | $\pm 0.46$ |
| Engineering (n=30)  | 14.0a                    | $\pm 0.43$ |
| Liberal Arts (n=108)  | 14.5a                    | $\pm 0.66$ |
| Business (n=71)   | 14.7a                    | $\pm 0.46$ |
| Education (n=61)  | 14.9a                    | $\pm 0.35$ |
| Other science (n=71)  | 15.0a                    | $\pm 0.43$ |
| Natural science (n=62)  | 17.0b                    | $\pm 0.77$ |

Maximum total knowledge score = 24.

\*Means followed by the same letter are not statistically different from one another ( $P < 0.01$ ).

The increase in total knowledge scores between the control and treatment groups did not vary in any predictable trend with degree category (Table 4).



| Table 4 - Increase in Total Knowledge Score<br>Between the Control and Treatment Groups in the<br>Estuary Trail Education Study, by Degree. |  |
|---|--|
| Degree  | Mean increase in Total<br>Knowledge Score. |
| Natural Science   | +2.9                                       |
| Other Science   | +2.9                                       |
| Engineering   | +2.1                                       |
| Education   | +2.2                                       |
| Liberal Studies   | +3.1                                       |
| Business  | +2.5                                       |
| Technical/other   | +3.2                                       |

The mean knowledge score of respondents who had been on the HMSC trail previously ( $\bar{X}=15.2$ ,  $SE\pm 0.36$ ,  $n=108$ ) was the same as participants who had not ( $\bar{X}=14.7$ ,  $SE\pm 0.16$ ,  $n=514$ ) ( $F=1.521$ ,  $df=1,620$ ,  $P=0.2179$ ). There was no interaction between treatment group and previous visit to the trail ( $F=1.706$ ,  $df=2,616$ ,  $P=0.1825$ ). The mean total knowledge score of individuals who had visited another estuary trail ( $\bar{X}=14.7$ ,  $SE\pm 0.21$ ,  $n=352$ ) was higher than the score for those who had not ( $\bar{X}=13.5$ ,  $SE\pm 0.17$ ,  $n=533$ ) ( $F=18.209$ ,  $df=1,883$ ,  $P<<0.001$ ). There was no interaction between treatment group and visit to another trail ( $F=3.386$ ,  $df=3,877$ ,  $P=0.0177$ ).

The mean total knowledge score for the individuals who stated they live within ten miles of a wetland was significantly higher than the scores for those who did not and those who were not sure ( $F=12.953$ ,  $df=2,886$ ,  $P<<0.001$ ).

The scores were 14.6 ( $SE \pm 0.18$ ,  $n=508$ ), 13.3, ( $SE \pm 0.23$ ,  $n=318$ ), and 12.6 ( $SE \pm 0.68$ ,  $n=61$ ) respectively.

The participants who responded yes to the question "Are you aware of wetland controversies in your area?" had a mean knowledge score of 14.2 ( $SE \pm 0.16$ ,  $n=624$ ) which was higher than the score of 13.4 ( $SE \pm 0.26$ ,  $n=244$ ) received by participants who were not aware of wetland controversies in their area ( $F=7.153$ ,  $df=1,866$ ,  $P=0.0076$ ).

Respondents who were or who had been members of a conservation organization showed a mean knowledge score of 15.1 ( $SE \pm 0.19$ ,  $n=374$ ). That score was higher than the 13.1 ( $SE \pm 0.18$ ,  $n=507$ ) score received by the respondents who were not ( $F=50.820$ ,  $df=1,879$ ,  $P < 0.001$ ).

There was no difference in total knowledge scores of participants with different numbers of people in their party ( $F=3.313$ ,  $df=4,759$ ,  $P=0.0105$ ). Participants who were in the company of two children had lower scores than those who were not with children or who had one child ( $F=5.702$ ,  $df=3,759$ ,  $P=0.0007$ ) (Table 5). The naturalist group was excluded from these comparisons because some naturalist participants filled in the total number of people and/or of children on the naturalist walk.

| Table 5 - Mean Total Knowledge Score by Number of People Under the Age of Fifteen in the Participants Party |                            |            |
|---|----------------------------|------------|
| Number of People Under the Age of Fifteen in the Participants Party   | Mean Total Knowledge Score | SE         |
| 0 (n=473)   | *14.0a                     | $\pm 0.19$ |
| 1 (n=97)  | 14.0a                      | $\pm 0.42$ |
| 2 (n=124)   | 12.4b                      | $\pm 0.37$ |
| 3+ (n=69)   | 12.8ab                     | $\pm 0.50$ |

Maximum score = 24.

Means followed by the same letter are not statistically different from each other ( $P < 0.01$ ).

#### Attitude Scores by Study Group

None of the mean attitude scores were significantly different among the four study groups ( $F=0.831$ ,  $df=3,835$ ,  $P=0.4771$ ). The scores were: control, 52.1; sign, 52.4; brochure, 52.2; and naturalist, 53.3.

#### Total Knowledge Score by Attitude Score

Mean Knowledge and attitude scores were graphed on a scatterplot to determine the correlation between the two (Figure 5). While there was a correlation between knowledge and attitude, the results have little predictive value ( $r=0.29$ ,  $F=77.034$ ,  $df=1,830$ ,  $P < 0.001$ ). While participants in the top 21% of knowledge scores had a mean attitude score of 54.4 or 91%, those in the lowest 22% of knowledge scores averaged 49.4 or 82% on the attitude statements.

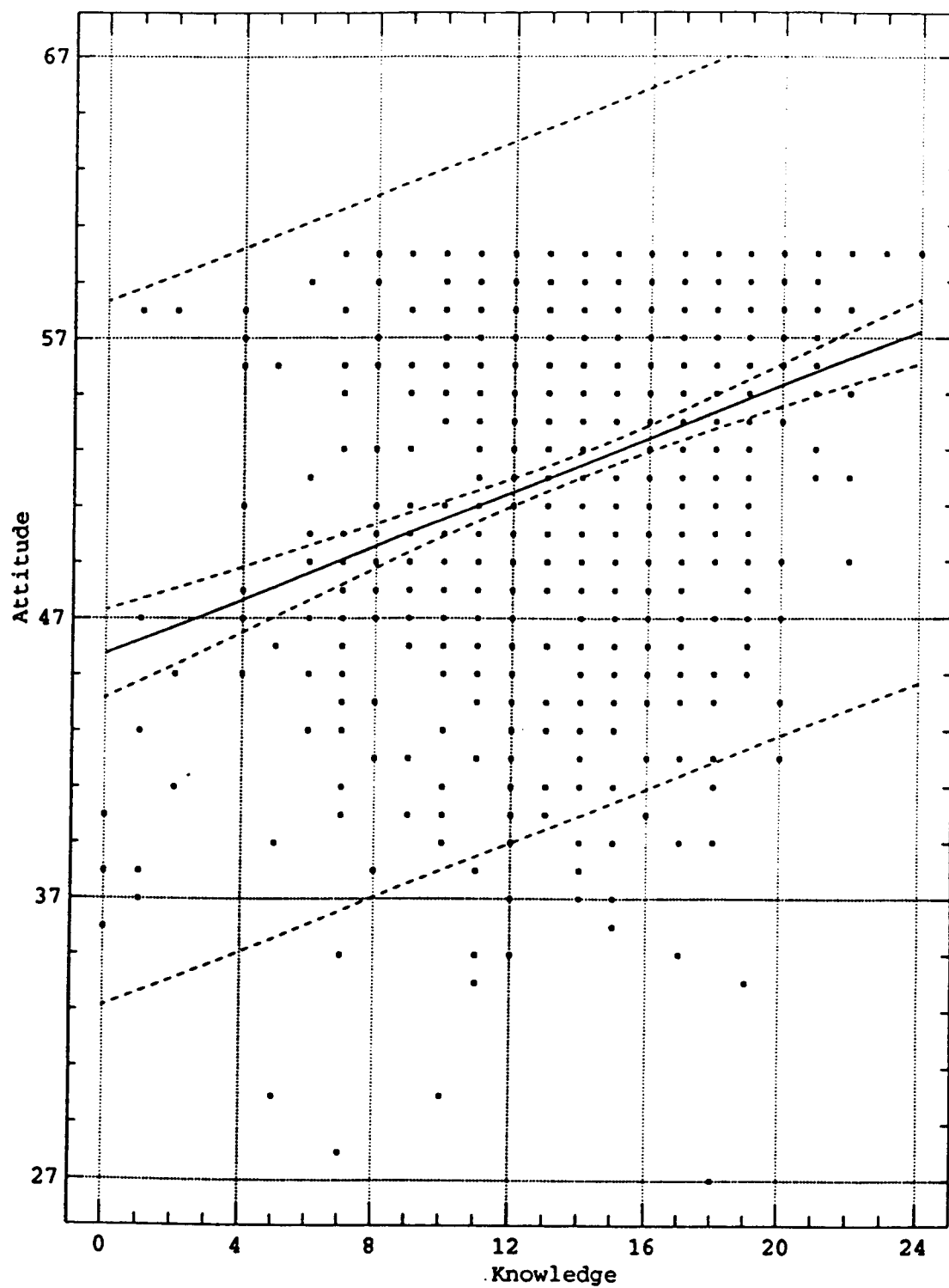


Figure 5: Mean Total Knowledge Score by attitude score of participants in the HMSC estuary trail informal education study.

### Attitude Scores by Demographics

I compared attitude scores to demographics and other visitor characteristics. There was no difference in scores between males ( $\bar{X}=52.4$ ,  $SE\pm 0.34$ ,  $n=370$ ) and females ( $\bar{X}=52.6$ ,  $SE\pm 0.31$ ,  $n=437$ ) ( $F=0.049$ ,  $df=1,804$ ,  $P=0.8270$ ).

The mean attitude scores of participants in the different age groups ranged from a low of 51.1 to a high of 53.2. There was no difference between attitude scores with regard to age ( $F=1.551$ ,  $df=5,828$ ,  $P=0.1714$ ).

Attitude scores increased with level of education (Figure 6). The mean score received by high school graduates was lower than each of the three other categories and the attitude score of participants with some college was lower than the score of college graduates and those with post graduate education ( $F=14.573$ ,  $df=3,811$ ,  $P<<0.001$ ). There was no difference in mean attitude scores received by individuals in each degree category ( $F=1.979$ ,  $df=6,397$ ,  $P=0.0676$ ). The scores ranged from 51.9 ( $SE\pm 1.18$ ) for engineering to 55.8 ( $SE\pm 0.79$ ) for natural science (Table 6).

The 106 participants who had been on the HMSC estuary trail before had a mean attitude score of 53.5 ( $SE\pm 0.64$ ). That score did not differ from the mean score of 52.4 ( $SE\pm 0.25$ ) received by the 481 participants who had not ( $F=2.269$ ,  $df=1,585$ ,  $P=0.1325$ ). The control group was excluded from this analysis.

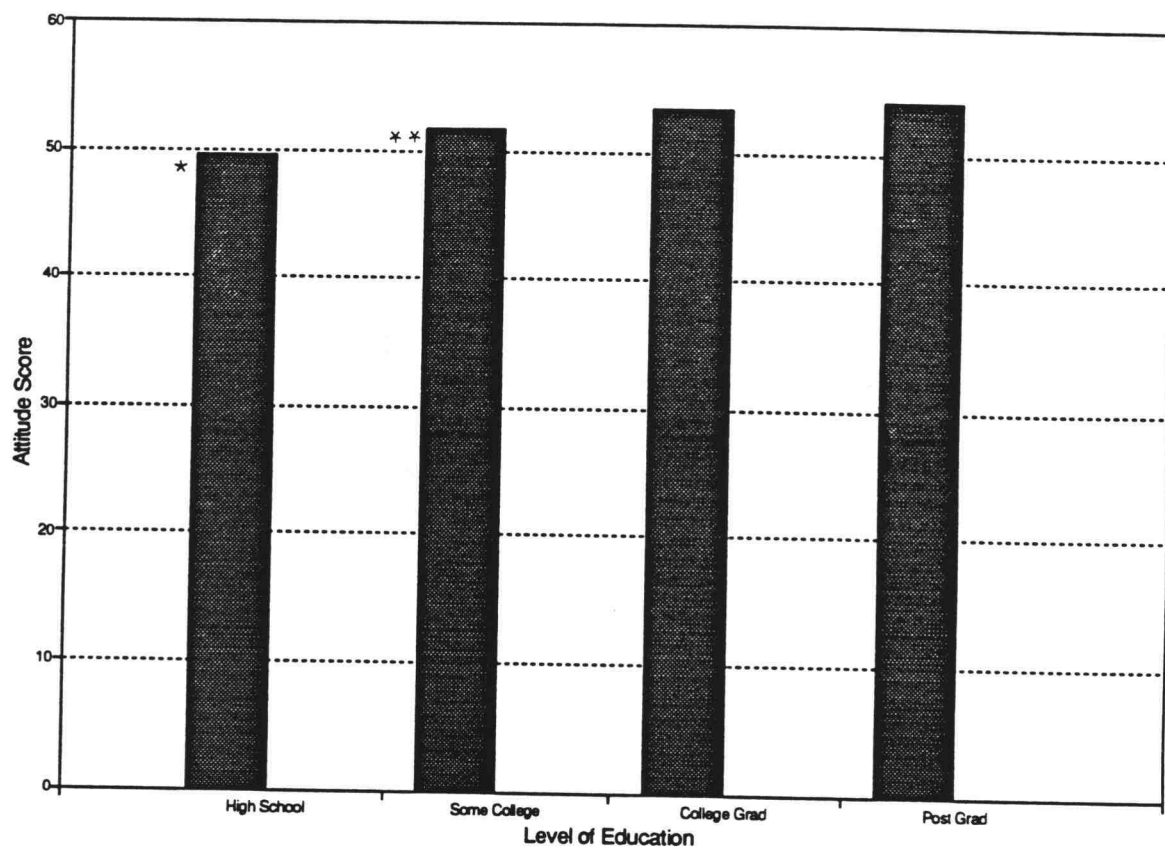


Figure 6: Mean attitude score by level of education of participants in the HMSC estuary trail informal education study.

\*Score lower than all other groups.

\*\*Score lower than college graduates and post graduates.  
( $P < 0.001$ )

| Table 6 - Mean Attitude Score by College Degree of Participants in the Estuary Trail Education Study. |                |            |
|---|----------------|------------|
| Degree  | Attitude Score | SE         |
| Natural Science (n=61)  | 55.8           | $\pm 0.79$ |
| Other Science (n=66)  | 53.7           | $\pm 0.76$ |
| Engineering (n=28)  | 51.9           | $\pm 1.17$ |
| Education (n=57)  | 53.2           | $\pm 0.82$ |
| Liberal Arts (n=105)  | 54.1           | $\pm 0.60$ |
| Business (n=66)   | 53.2           | $\pm 0.76$ |
| Technical/Other (n=21)  | 55.4           | $\pm 1.35$ |

Maximum attitude score = 60.

The attitude score of those who had visited another estuary trail before ( $X=53.6$ ,  $SE\pm 0.38$ ,  $n=336$ ) was significantly higher than the score of those who had not ( $X=51.6$ ,  $SE\pm 0.33$ ,  $n=497$ ) ( $F=17.336$ ,  $df=1,830$ ,  $P<<0.001$ ).

Participants who lived within ten miles of a wetland had higher attitude scores than those who did not and those who were not sure ( $F=8.648$ ,  $df=2,831$ ,  $P=0.0002$ ) (Table 7).

| Table 7 - Mean Attitude Score by Residence Proximity to Wetlands of Participants in the Estuary Trail Education Study. |                     |            |
|--|---------------------|------------|
| Living Within Ten Miles of a Wetland   | Mean Attitude score | SE         |
| Yes (n=483)  | 53.2a*              | $\pm 0.32$ |
| No (n=293)   | 51.5b               | $\pm 0.41$ |
| Not Sure (n=58)  | 50.2b               | $\pm 0.89$ |

Maximum attitude score = 60.

\*Means followed by the same letter are not statistically different from each other.

A relatively large difference in attitude scores were seen between the 356 individuals who were or who had been members of a conservation organization and the 473 individuals who were not. Those mean scores of 55.2 ( $SE \pm 0.29$ ) and 50.6 ( $SE \pm 0.31$ ) were significantly different ( $F=110.395$ ,  $df=1,826$ ,  $P=0.0000$ ).

The mean attitude score of participants who were aware of wetland controversies in their community ( $\bar{X}=53.4$ ,  $SE \pm 0.26$ ,  $n=589$ ), was significantly higher than the mean score for those who were not ( $\bar{X}=50.3$ ,  $SE \pm 0.44$ ,  $n=230$ ) ( $F=36.820$ ,  $df=1,816$ ,  $P < 0.001$ ).

There was no difference in the attitude scores of participants with different numbers of people in their party ( $F=0.592$ ,  $df=4,716$ ,  $P=0.6687$ ). The scores ranged from 51.5 to 52.7. There was also no difference in attitude scores of participants who are in the company of children and those who are not, nor between participants with one, two, or three or more children ( $F=2.378$ ,  $df=3,715$ ,  $P=0.0678$ ).

### Study Group Demographics

Prior to analyzing the knowledge and attitude scores, demographics and other visitor characteristics were compared between study groups. The goal of this comparison was to assess any large differences between groups that could account for differences in knowledge and attitude scores. With the exception of the characteristics, previous visits



to the HMSC estuary trail and previous visits to another estuary trail, there were no significant differences in participants in the four study groups.

The percent participation of males and females for each study group was representative of the overall study; 52% female and 44% male (4% of the participants circled both male and female) ( $X^2=9.3$ ,  $df=6$ ,  $0.10 < P < 0.25$ ) (Appendix V, Table 1). There was an even distribution in the study groups of the six categories of age assigned to this project ( $X^2=9.08$ ,  $df=15$ ,  $0.75 < P < 0.90$ ) (Appendix V, Table 2).

The education of participants in each study group was generally representative of the overall study ( $X^2=8.46$ ,  $df=12$ ,  $0.50 < P < 0.75$ ) (Appendix V, Table 3). The participation of college graduates and post graduates by degree was also fairly uniform between the study groups ( $X^2=14.55$ ,  $df=18$ ,  $0.50 < P < 0.75$ ) (Appendix V, Table 4).

In response to the question, "Have you been on this estuary trail before?", 16% of the overall sample responded yes. The responses from the study groups were sign 23%, brochure 15% and naturalist 6% ( $X^2=18.13$ ,  $df=2$ ,  $P < 0.001$ ). The percent for the control group, who were determined not to have been on the trail before, was zero.

When asked whether they had been on another estuary trail before, 40% of the participants said yes. The group responses were divided; 44% for the sign and brochure groups

and 34% for the control and naturalist groups ( $X^2=9.33$ ,  $df=3$ ,  $0.025<P<0.05$ ).

Participants were asked whether they currently are or ever have been a member of a conservation organization. The yes response was approximately 42% for all study groups ( $X^2=0.18$ ,  $df=3$ ,  $0.975<P<0.99$ ). When asked whether they live within ten miles of a wetland, the study groups were generally representative of the study as a whole ( $X^2=8.82$ ,  $df=6$ ,  $0.10<P<0.25$ ) (Appendix V, Table 5). In response to the question, "Are you aware of wetland controversies in your community?", 65 to 72% of participants in all groups said yes ( $X^2=3.05$ ,  $df=3$ ,  $0.25<P<0.50$ ).

Participants were asked to write in the number in their party and the number under the age of fifteen. Excluding the naturalist group, 43 to 50% of the participants in each group were with one other person; the remaining were by themselves or with two or more people ( $X^2=6.76$ ,  $df=8$ ,  $0.50<P<0.75$ ) (Appendix V, Table 6). Looking at numbers in the party under the age of fifteen, the percent of participants in the study groups with zero, one, two, or three or more children, was representative of the study average ( $X^2=1.69$ ,  $df=6$ ,  $0.95<P<0.975$ ) (Appendix V, Table 7).

### Visitor Behavior

Visitor Counts: During the period of the study, visitor trail use by month, (excluding August - October

1991) varied from a low of 1999 for December 1991, to a high of 7265 for May 1992 (Table 8). The high numbers seen in the months of March, April and May 1992 may be attributed to the number of school groups which use the trail during those months for special educational programs. Visitor counts were recorded through May 1993 when the estuary trail was extended to the Oregon Coast Aquarium (Appendix VI).

| Table 8 - Visitor Use of the HMSC Estuary Trail During the Education Study, by Month. |                    |
|---|--------------------|
| August to October 1991  | Data not available |
| November 1991   | 2338               |
| December 1991   | 1999               |
| January 1992  | 2178               |
| February 1992   | 2554               |
| March 1992  | 5575               |
| April 1992  | 5090               |
| May 1992  | 7265               |
| Total   | 26,999             |

Visitor Observations: A total of 89 visitors from 76 parties were observed during all or part of their walk along the HMSC estuary trail during the summer and fall. Of the 76 parties, 22 (28%) were in the company of from 1 to 4 children.

The total time spent on the trail was collected for 43 parties. These groups spent an average of 16 minutes

(SD±11.18) from their entrance to exit time, and ranged from 1 to 42 minutes.

Sixty-nine parties were observed until they turned around and headed back to the beginning. Of that number, 28 (41%) parties walked all the way to the end of the trail; 41 (59%) turned around before reaching the end (Table 9). Of the parties that were observed turning to exit before they reached the end of the trail, 15 (37%) were with children.

| Table 9 - Distance Traveled Along the HMSC Estuary Trail by Observed Parties. |  |
|---|--|
| Number of Parties   | Distance Traveled Along Estuary Trail. |
| 5   | Sign 1                                 |
| 10  | Sign 2                                 |
| 7   | Sign 3                                 |
| 7   | Sign 4                                 |
| 9   | Sign 5                                 |
| 1   | Sign 6                                 |
| 2   | Sign 7                                 |
| 28  | End of Trail                           |

Twenty-one parties were observed going from the estuary trail to the beach during their walk (Table 10). Eight of these parties (38%), were in the company of children.

| Table 10 - Parties Observed Going to the Beach During Their Walk on the HMSC Estuary Trail. |                                       |
|---|---------------------------------------|
| Number of Parties   | Location Where They Went to the Beach |
| 6   | Sign 2                                |
| 3   | Sign 3                                |
| 2   | Sign 4                                |
| 10  | Sign 5                                |

Individual visitors were observed in front of the interpretive signs. At each sign, between 54 and 77% of the visitors were observed reading the information (Table 11). Those who did read the signs were timed; the average time spent reading each sign ranged from 16 seconds for Sign 2, to 39 seconds for Sign 5 (Table 12).

| Table 11 - Visitor Observations at Interpretive Signs along the HMSC Estuary Trail. |                             |                                     |                          |
|---|-----------------------------|-------------------------------------|--------------------------|
| Sign #  | Number of Visitors Observed | Number of Visitors Observed Reading | Percent Observed Reading |
| 1   | 57                          | 31                                  | 54                       |
| 2   | 55                          | 39                                  | 71                       |
| 3   | 45                          | 35                                  | 77                       |
| 4   | 36                          | 25                                  | 69                       |
| 5   | 28                          | 17                                  | 61                       |
| 6   | 32                          | 22                                  | 69                       |
| 8   | 32                          | 22                                  | 69                       |
| 9   | 31                          | 23                                  | 74                       |

| Table 12 - Amount of Time Visitors Observed Reading the<br>Interpretive Signs Along the HMSC Estuary Trail.<br>(in seconds)<br>(data excluding reading times of 0) |                                  |                                     |                                     |
|--|----------------------------------|-------------------------------------|-------------------------------------|
| Sign #   | Mean Time<br>Observed<br>Reading | Minimum Time<br>Observed<br>Reading | Maximum Time<br>Observed<br>Reading |
| 1  | 22                               | 2                                   | 61                                  |
| 2  | 16                               | 1                                   | 43                                  |
| 3  | 26                               | 1                                   | 75                                  |
| 4  | *30                              | 11                                  | 46                                  |
| 5  | *33                              | 14                                  | 67                                  |
| 6  | *24                              | 11                                  | 47                                  |
| 8  | *27                              | 3                                   | 77                                  |
| 9  | *25                              | 5                                   | 53                                  |

\*Outliers greater than two Standard Deviations away from the mean were deleted. A total of seven outliers were removed; three from sign 4 and one each from signs 5, 6, 8 and 9.

## DISCUSSION

The primary objective of this study was to determine whether exposure to the interpretive programs on the HMSC estuary trail affects visitors knowledge of estuarine ecology. Specifically, this objective was to analyze the three HMSC estuary trail educational programs: interpretive signs, a self-guided trail brochure, and guided walks. The other main objective was to determine visitors attitude toward estuarine and wetland conservation issues, and to determine whether knowledge and attitude are correlated. Finally, this study includes an analysis of visitors knowledge and attitude with respect to demographics and other visitor characteristics.

### Visitors Knowledge of Estuarine Ecology

Exposure to the HMSC education programs on the estuary trail resulted in higher knowledge of estuarine ecology as tested by this study. Participants in the treatment groups scored an average of 62% on the knowledge test, 12% higher than the control group. This was a significant difference and an indication that visitors did learn from the estuary trail programs.

My results are similar to other studies; Eason and Linn (1975) found a 10% increase in knowledge scores and Borun and Miller (1979) showed a 13% increase. Other researchers

with slightly larger increases attributed their results to their test design which used visuals instead of written question (Borun 1977, Hammitt 1984).

An ongoing question in visitor learning studies is the assessment of how much learning is indicative of the success of a program; an assessment that is more difficult to evaluate than studies of formal programs where expectations for learning have been set. One difficulty in establishing a set of success criteria lies in the nature of program participants. Informal program participants are leisure-oriented. They may visit a facility with the intent of learning, however, they do not expect to expend a lot of effort to learn. Learning often is second in importance to other expectations such as entertainment and family interaction (Rosenfeld 1980, Screven 1986).

Informal education programs must also compete with many other stimuli for audience attention, a characteristic that can affect program success to different degrees depending upon the setting. On the HMSC estuary trail, the educational programs are competing with the scenery, boats, wildlife, the weather, other people and all the other sights and sounds of the estuary.

Because of the visitors social expectations, the effort they are willing to invest in acquiring knowledge, and the competing stimuli for audience attention, the goals for success that educators in informal settings establish must



be different from academic program goals. Serrell (1992) has proposed the "51% solution". If 51% of the visitors can quote or recall 51% of the facts or concepts from the program, then it is successful. Borun (1977) had similar criteria for success. She noted that since her study dealt with casual visitors whose primary goal was entertainment, it was impressive that they left the museum knowing over half of the tested information content of the exhibits. Visitors to the HMSC estuary trail leave knowing an average of 62% of the tested information. Considering the goals and expectations of visitors, and the competing stimuli on the estuary trail, these results indicate that the HMSC education programs are successful in communicating information on the ecology of estuaries.

It appears that there may be a limit to the amount of program-based learning that is possible in the unstructured environment of an informal learning center. Shettel et al. (1968) used a control group of paid subjects who were instructed to learn as much of the exhibit as they could before they were tested. Their scores never went above 75%. He suggested this may be the limit of the amount of information that can be communicated to the casual visitor. That limit appears to range between 50 and 75% of the presented information (Shettel et al. 1968, Borun 1977). The three HMSC estuary education programs, with a combined treatment knowledge score of 62% and individual group

knowledge scores between 63 and 73%, were in the mid to high end of this range of potential audience learning limits. These results indicated that each program was a success.

If the HMSC estuary programs are successfully imparting knowledge to participants on the ecology of estuaries, are they contributing to visitors scientific literacy? By Shen's (1975) definition, scientific literacy includes an understanding of science and confidence in one's ability to make scientific decisions. While this study did not address individual confidence in an ability to make decisions, my results do show that knowledge of estuarine ecology (science) does increase with program exposure. Therefore, I would suggest that the HMSC programs do increase the visitors understanding of science and are contributing to participants scientific literacy.

#### Relative Effectiveness of the Three Education Programs

An analysis of the three individual interpretive programs indicated that exposure to each of the programs did result in a higher knowledge of estuarine ecology as tested by this study. The group knowledge scores, which looked specifically at those questions that each group was exposed to on the HMSC estuary trail, showed that each of the treatment groups had significantly higher scores than the corresponding control group.

If success of a program is determined, as in this case, by the number of correct responses to a set of questions as compared to a control, the naturalist program was the most successful of the HMSC estuary trail educational programs. Participants in this program scored 73% on their set of questions; 22% higher than the control group. The brochure group scored 15% higher than the control group on brochure questions and the sign group's score was 11% higher than the control. While each program was successful, the naturalist program was the most effective at transferring information to visitors.

There are a number of possible explanations for the relative success of the naturalist program. The amount of time that visitors are involved in a program may have an affect on learning. The naturalist walks generally lasted 30 minutes to one hour depending upon the staff, the interest of the visitors, and the weather. Visitor observations on sign group participants conducted in the summer and fall showed that parties spent an average of 16 minutes from their entrance to exit time. While no comparison is available for the brochure group, or the other seasons, it is apparent that for those two seasons participants on the naturalist walk spent more time on the trail than those who were reading the interpretive signs. That extra time for the audience may translate into a deeper

involvement in the program and a greater opportunity for learning to occur.

Another possibility for relative success of the naturalist program is the presence of a person in the role of a guide. Museum and nature trail audiences come to the facility with diverse backgrounds and interests (Falk et al. 1986, Screven 1986). An ongoing challenge to educators is to design programs that will appeal to this heterogeneous audience. An effective interpreter can do what no written text can do, adapt to the needs, interests, and comprehension level of the audience. While still conveying the same information, a guide can answer questions, spark interests and clarify points that may go unanswered in visitors who are reading a sign or a brochure.

Screven (1968) pointed out that informal learning must be fun; it must be enjoyable or the visitors will not participate. It may be that participating in a walk with a naturalist is more fun than reading a sign or a brochure. An effective naturalist can help make the program enjoyable which may translate into more participation and attention to learning in the visitors.

Another audience characteristic that can affect learning is the leisure-orientation of visitors. Visitors come to an informal learning center on their free time and they choose whether or not they will become involved in a program (Falk et al. 1986, Screven 1986). Leisure-oriented

audiences do not want to work very hard at learning. Going along a guided walk and listening to a naturalist in some ways requires less effort than carrying a brochure and reading it or reading a sign. An interesting naturalist who explains concepts and principles clearly, and who incorporates the sights, sounds and smells of the setting into the presentation, can greatly facilitate learning.

While comparable data are not available for the brochure group, observations of sign group visitors in the summer and fall seasons may help explain their knowledge results. Out of the 69 parties observed until they turned around and headed back to the beginning of the trail, 59% turned around before they reached the end of the trail. Generalizing these results to sign group participants as a whole, it appears that the majority of the visitors do not travel the entire length of the trail and do not see all of the interpretive signs, a possible explanation for their relatively low knowledge gains over the control compared to the other two groups.

The attraction and holding power of an exhibit are important characteristics in whether learning will occur. Attraction is based on criteria such as exhibit design and the personal interests and background of the visitor. Once visitors' attention has been attracted, they will spend varying amounts of time, (holding power) in front of the display, again dependent upon criteria such as their

interest, their expectations and the exhibit design (Falk et al. 1986). If a display can attract and hold a visitors' attention, he/she are likely to read the text associated with the display (Borun and Miller 1979).

Along the HMSC estuary trail, between 33 and 46% of the visitors did not read the interpretive signs; this is an indication that the signs did not attract their attention and they did not learn from that educational program.

In this study, holding power was measured by the amount of time visitors spent reading the educational signs. I found that visitors spent an average of between 16 and 33 seconds reading the sign text, similar to other conclusions that the average visitor spends less than 30 seconds before an exhibit (Koran et al. 1983).

Researchers have suggested that any time a visitors attention is focused in an appropriate manner on an exhibit for a significant amount of time, learning occurs (Falk et al. 1986, Falk and Balling 1982). Yet there is no agreement in the literature as to what is significant. It has been suggested that significant would be the amount of time it takes an average reader to read the text (DeMouthe 1989). Sheppard (1960) suggested getting a standard time by instructing other people to read the exhibit and then establishing a standard reading time. Miles and Tout (1979) proposed using a holding power ratio; viewing time divided by minimum viewing time, as an index of effectiveness.

To establish a criteria for the holding power of the HMSC estuary signs, I asked other individuals to read the signs and time themselves. From their results I assigned a minimum reading requirement for each sign based on the lowest time a person reported reading that sign (Table 13). A comparison of tables 12 and 13 shows that the mean time participants in this study spent reading the signs was less than the minimum reading requirement for all but sign number 1. This indicates that the average visitor to the HMSC estuary trail does not take enough time to completely read the interpretive signs. In addition, the average time participants spent reading the signs was 30 seconds or less for each sign except number 5. Koran et al. (1983) noted that 30 seconds is barely enough time for transferring information into long term memory, again, an indication that visitors do not spend enough time reading the signs to learn the information.

While the signs were effective in teaching visitors about the ecology of estuaries, the combined effects of visitors not traveling the entire length of the trail, a large percent of visitors observed not reading the signs, and the short reading times, all contributed to the relatively low increase in knowledge scores for the sign group as compared to the naturalist group.

| Table 12 - Amount of Time Visitors Observed Reading Interpretive Signs<br>(in seconds)<br>(data excluding reading times of 0) |                            |                               |                               |
|---|----------------------------|-------------------------------|-------------------------------|
| Sign #  | Mean Time Observed Reading | Minimum Time Observed Reading | Maximum Time Observed Reading |
| 1   | 22                         | 2                             | 61                            |
| 2   | 16                         | 1                             | 43                            |
| 3   | 26                         | 1                             | 75                            |
| 4   | *30                        | 11                            | 46                            |
| 5   | *33                        | 14                            | 67                            |
| 6   | *24                        | 11                            | 47                            |
| 8   | *27                        | 3                             | 77                            |
| 9   | *25                        | 5                             | 53                            |

\*Outliers greater than two Standard Deviations away from the mean were deleted. A total of seven outliers were removed; three from sign 4 and one each from signs 5, 6, 8 and 9.

| Table 13 - Minimum Reading Time Requirement for the Interpretive Signs<br>(in seconds) |                      |
|--|----------------------|
| Sign Number  | Minimum Reading Time |
| 1  | 20                   |
| 2  | 22                   |
| 3  | 40                   |
| 4  | 25                   |
| 5  | 37                   |
| 6  | 26                   |
| 8  | 38                   |
| 9  | 41                   |



### Demographic Characteristics and Knowledge Scores

Visitors in this study who were college graduates or post graduates had significantly higher total knowledge scores than those with less than a college degree. This finding is consistent with other studies (Griggs 1983, Shettel et al. 1968). However, while total knowledge scores increased with increasing education for study participants as a whole, the difference in knowledge scores between the control group and the treatment groups did not increase with education (Table 2). At each education level, the knowledge gain from program exposure was between 11 and 12%. While a higher level of education corresponded to a higher score, it did not correspond to a larger increase in scores. These results indicate that the HMSC programs are successful with visitors at all educational levels.

Visitors who had a natural science background had significantly higher scores than those in all other degree categories. Again, results similar to these were documented in other studies (Shettel et al. 1968, Borun and Miller 1979). Borun and Miller (1979) found that control and treatment participants with a science background had the same score whereas treatment participants without a science background had higher scores than the controls. Their results indicate that individuals with a science background did not learn additional information. Other authors have concluded that prior knowledge of a subject is an important

an important variable in the amount visitors learn, and possibly a criteria for learning (Shettel et al. 1968, Wittrock 1979). However, my findings do not concur. The gain in knowledge scores between the control and treatment groups for individuals with a natural science background was 12%; the gain for all other degree categories was between 9 and 13%. These results show the HMSC programs effectively educate participants from all academic backgrounds.

Visitors who were members of a conservation organization had higher knowledge scores than non-members. Conservation organization members also had more formal educational experience than non-members, with 70% holding college degrees or higher compared to 43% for non-members. While it may be that members of conservation organizations have higher scores by virtue of their educational background, their scores may also be attributed to information they have been exposed to through their organization. Many conservation organizations (e.g. the Sierra Club and Audubon Society) provide information on ecological and conservation-oriented topics for their members through newsletters, journals, workshops, conferences and meetings.

While conservation organization members had higher scores than non-members, the gain in knowledge for members and non-members was exactly the same, 2.8 points (12%);

another indication that the HMSC programs are effectively communicating to visitors from different backgrounds.

My study also shows that participants who had been to the HMSC estuary trail or another estuary trail before had higher knowledge scores than those who had not. Fortner and Lyon's (1984) study found that on a two week retention test participants knowledge score decreased, but was still significantly higher than the pretest. I conducted no retention test nor did I ask participants whether the other trail included an educational program; however, it appears that there was some retention of information from previous visits to an estuary trail.

Participants who stated they live within ten miles of a wetland and those who were aware of wetland controversies in their area had higher scores than those who did not. While these differences were not as large as the previous characteristics, they do indicate some effect. For residence proximity to wetlands, it is most likely not the actual location, but information associated with the location such as newspaper articles about wetlands and wetland education programs, that would contribute to higher scores. The demographics of this study show that participants who live within ten miles of a wetland and individuals who are aware of wetland controversies in their area have more formal education than their those who do not and are not. I suggest it is not that individuals who live

close to wetlands are more highly educated, but that individuals with a higher level of education have a greater understanding of what a wetland is and their proximity to it. Individuals with more formal education experience may be more likely to keep abreast of environmental issues, increasing their awareness of local wetland controversies.

Formal education is the greatest factor contributing to a visitors background knowledge of this subject. Individuals who are well educated are likely to continue to seek out informal educational opportunities throughout their life. However, while the educational history of a participant does contribute to their background understanding of the topic, it is not a prerequisite for learning the information presented along the HMSC estuary trail.

#### Visitors Attitudes Towards Conservation Issues

The attitude scores in this study indicate that there is no difference in visitors attitude towards conservation issues after participation in an estuary trail education program. The mean attitude score of the control group was not different from the treatment groups taken as a whole, or individually. Nor were any of the treatment groups different from each other. While the attitude score of the naturalist group was 89% positive towards conservation in

wetland related issues, the other groups, including the control, averaged 87%.

Attitudes, as defined by Rokeach (1975) are "relatively enduring organizations of beliefs about objects or situations". Whether informal educational programs affect attitude has been the subject of debate. Although Shettel (personal communication, 1992) has noted that people can have an attitude change through a one-time visit to an exhibit, Birney (personal communication, 1992) suggests that sustainable experiences such as memberships in an organization and ongoing educational programs (zoo camps, museum lecture series, film series) are the experiences that can affect individual views. George (1967) concluded that in terms conservation, it takes many experiences to establish and reinforce favorable attitudes. A conclusion similar to Fortner and Lyon's (1984) that attitudes appear to develop by small incremental changes that may eventually be recognized as new beliefs.

The HMSC estuary programs last a maximum of one hour. This is a relatively short period of time in the life of an adult who quite possibly has already formed attitudes and opinions about wetland conservation issues through exposure to the media, books, family, friends and all of the other agents of attitude formation. In addition, the HMSC educational programs were not designed to change attitudes. The goal was to produce an informed public. While the HMSC

Aquarium mission statement does include the goal to "increase public appreciation of marine and coastal environments" (OSU: HMSC 1992), the intent of that statements is an increase in awareness (Weber, HMSC, personal communication 1993). Consequently, given the length of the estuary programs and the goals of the HMSC, it is not surprising that attitude scores did not change with program exposure.

Surprisingly, knowledge of estuarine ecology did not correlate with positive attitudes towards estuarine conservation issues. These results differ from other studies where authors have found a positive correlation between knowledge and attitude (Olson et al. 1984, Fortner and Teates 1980, Cohen, 1973, Hounshell and Liggett 1973, Richmond 1976). However, when I looked at the top and bottom 20% of the participants by knowledge score, I found their attitude scores differed by 9 percentage points. While the attitude score for participants as a whole was 87.5%, those who scored in the top 20% of knowledge had an attitude score of 91% and those who scored in the bottom 20% had an attitude score of only 82%. Fortner and Teates (1980) found similar results when they looked at the top and bottom 15% of their participants. So, while knowledge and attitude were weakly associated in the study as a whole, the highest and the lowest knowledge levels are associated with different attitude scores.

### Demographic Characteristics and Visitors Attitudes

A visitors formal education is associated with attitude. As the level of participants education increased, so did positive attitudes towards wetland conservation issues. While the difference between college graduates and post graduates was slight, differences between all other education levels were significant.

Surprisingly, attitude did not differ with degree. Specifically, those with natural science degrees did not have higher attitude scores than individuals in the other degree categories. These results are similar to the findings of Hoover and Schutz (1963) who concluded that "ordinary science education" has little impact on basic conservation attitudes. The authors suggest that the approach of teachers and textbooks, with an emphasis on learning the facts of conservation, may be ineffective in developing positive conservation attitudes.

The attitude scores of conservation organization members were higher than non-members. This result is expected as individuals who become members of conservation organizations are likely to hold conservation-oriented opinions about environmental issues. Somewhat smaller yet still significant differences were seen between participants who live within ten miles of a wetland and those who do not, and participants who were aware of wetland controversies in their area and those who were not. Similar to my conclusion

from the knowledge results, I suggest that it is not the location per se that affects attitude, but that conservation-oriented visitors are more aware of their proximity to wetlands and are more aware of environmental issues, including local wetland controversies.

In general, the conservation attitudes of visitors to the HMSC estuary trail appear to be positively correlated with formal education background. While exposure to an informal program has the potential to affect attitude, that is not a goal of the HMSC education programs. The HMSC goals focus on increasing visitors understanding and awareness of organisms and habitats.



## CONCLUSION

This purpose of this study was twofold. The first objective was to investigate visitors' gain in knowledge of estuarine ecology after exposure to an education program on the HMSC estuary trail. The second objective was to determine estuary trail visitors' attitudes towards estuarine and wetland conservation issues.

My results show that exposure to the estuary trail education programs increased visitors knowledge of estuarine ecology. Visitors who participated in each of three education programs, interpretive signs, self-guided trail brochures, and naturalist walks, scored significantly higher than the control group on a test of comprehension of estuarine ecology. The results further showed that all study groups, including the control group, were demographically the same.

The results of this project also show that the HMSC estuary education programs effectively educate visitors from all educational levels and backgrounds. At each level of education the gain in knowledge scores between the control and treatment groups was the same. And, the gain in knowledge for college graduates and post graduates was similar for all degree categories.

The results of the knowledge test were divided into three subtests based on the information that participants in

each program received. Those results, when compared to the control group, indicate that the naturalist walks were the most effective at transmitting information to HMSC visitors. The self-guided trail brochure was second to the naturalist walks in program success and the interpretive signs were the least effective.

I also investigated the question of whether the education programs have an effect on visitors attitudes. Participation in the estuary trail education programs does not affect a visitor's attitude towards estuarine and wetland conservation issues. This conclusion is not surprising given the high attitude scores of all HMSC trail visitors, 52.5 out of 60, and the relatively short duration of the programs which last a maximum of one hour. Furthermore, because the HMSC Aquarium goals do not include changing visitors' attitudes, the focus of the programs is not concentrated in that area. Therefore, an absence of attitude change does not indicate the programs were unsuccessful.

A commonly held belief in informal education is that increased understanding of a subject leads to an increase in appreciation of and attitude towards that subject. While I found a weak association between knowledge and attitude for study participants as a whole, participants with the highest and lowest knowledge scores had the highest and lowest attitude scores respectively. This indicates that those who

are moderately informed in estuarine ecology have a range of attitudes about estuarine and wetland conservation issues. Informal programs with a goal to change attitudes may want to concentrate their efforts on increasing the knowledge of visitors who are moderately informed; with a possible effect of increasing their attitude towards the subject of a program.

I compared visitor demographics to knowledge and attitude scores. Knowledge and attitudes both were associated positively with participants level of education. College graduates and post graduates who had studied the natural sciences had higher knowledge scores than individuals in all other degree categories. However, attitude scores did not vary with participants field of study. Aside from this latter finding, my study shows that the formal education of participants correlated with a greater understanding of the ecology of estuaries, and a conservation-oriented attitude towards wetlands.

Individuals who were members of conservation organizations had higher knowledge and attitude scores than non-members. The effects of formal education may contribute to the higher knowledge scores of members, however, the knowledge gained with exposure to the HMSC programs was the same for members and non-members. While conservation organizations and formal education may contribute to

visitors knowledge of ecology, the HMSC education programs are effective with both groups of participants.

Knowledge and attitude scores were also higher for individuals who lived within ten miles of a wetland and those who were aware of wetland controversies in their community. Again, these findings may be a result of educational background or of information associated with the participants residence.

The final visitor characteristics that correlated with high knowledge of estuarine ecology had to do with previous visits to estuary trails. Visitors who had been to the HMSC estuary trail and another trail had higher knowledge scores than those who had not. While my study did not address whether the other trail included educational programs, the results suggest that there is some long-term retention of information after exposure to an informal program.

The combined results of this project show that the HMSC, through its estuary trail programs, is successfully educating visitors on the ecology of estuaries. Each of the three programs were found to be effective in imparting information to the visitors, the naturalist walks being the most successful. Finally, certain visitor characteristics such as educational background, residence, and membership in a conservation organization are correlated with a greater knowledge of estuarine ecology, and attitude towards estuarine and wetland conservation issues.

## FUTURE RECOMMENDATIONS

In determining what educational programs to offer on the estuary trail, the HMSC, like all organizations, must weigh the cost and the benefits. Interpretive signs and a self-guided trail brochure, while initially expensive, require low maintenance once in place. Reprinting costs for the brochures may be kept at a minimum if visitors return them after their walk. The current sign on the brochure rack requesting users to return the brochure has met with nominal success. However, it may be more effective to have a sign that informs visitors that self-guided trail brochures are available for their use, and if they wish to keep them there is a cost. This method has proven effective at many National Parks.

The brochure used for the study was revised in June 1992 (Appendix VII) and the new brochure is currently available for use along the trail.

The naturalist program was staffed by HMSC volunteers. The expenses associated with the program include development and training, requiring approximately 40 hours of a staff members' time. In addition, there are ongoing time costs of scheduling, advising and answering volunteer questions.

In light of the results of this study, I believe that a volunteer naturalist program is worth the investment. The gain in visitors' understanding of estuarine ecology after

participation in the naturalist-led walks was significant. That gain in knowledge was much greater than the gains associated with the other two programs. The naturalist program is effective in teaching visitors about the ecology of estuaries and helping the HMSC Aquarium education staff to achieve their goals.

The benefits of a naturalist program extend beyond what the visitors learn about ecology. Volunteer naturalists can be ambassadors for their organization. Along with their teaching role, they can extend the goals and objectives of the facility to the visitors. Future studies may be beneficial if they address the question of visitors understanding of the purpose of the HMSC, and their attitudes towards the facility.

The naturalist program may also benefit the volunteer naturalists. As has been seen, an individuals' attitude towards a subject can be affected by long-term affiliation with an organization (Birney, 1992). Volunteer staff who are affiliated with the HMSC through their participation in the estuary naturalist program may be developing attitudes towards conservation that are influenced by that association.

If the HMSC continues to offer naturalist walks, there are some factors to consider. An important criterion for program success is to enlist the help of dedicated volunteers who are willing to spend the time and energy to

learn the material. Another criterion is to develop a well-run training program that clearly teaches the naturalists the scientific information and interpretive skills. And, there should be a staff member who is both knowledgeable about the subjects, and the skills of interpretation, who is available at regular intervals to answer questions and to provide support and encouragement for the volunteer naturalists.

Because guided walks are offered only once a day, and because the other two education programs were also effective in imparting knowledge on the ecology of estuaries to visitors, I recommend a continuation of those programs. However, it does not appear necessary to have signs and a brochure along the same trail. As the signs are relatively permanent structures located immediately adjacent to the paved trail, I recommend a brochure that leads visitors on an estuary beach walk. Many participants in this study were observed going to the beach from the trail; a self-guided beach walk would increase the possibility of educating those visitors. A self-guided beach walk may also encourage visitors to learn from both programs by enticing them to walk one way on the paved trail, reading the signs, and the other way along the beach, reading the brochure.

The development of a beach walk would involve a nominal cost. The brochure rack located at the beginning of the trail could remain, with the addition of a map on the front

indicating where the trail begins. The well-worn path from what was the survey station, (located between signs 2 and 3), to the beach, could serve as the starting point. Small numbered posts could be placed just above the high tide line at a minimum cost. A self-guided beach walk would not require the development of a new brochure because the stops on the current brochure can easily be adapted to a beach walk. However, the opening remarks should be replaced by a map of the beach walk, with a recommended point of return to the paved trail.

Observational data from this study showed that a relatively large percent of visitors did not walk the entire length of the trail. It is unknown if their reasons were personal, or due to site-specific factors such as weather, setting, educational programs or other factors. In May 1993, the trail was extended across the saltmarsh to the Oregon Coast Aquarium. Future studies may want to determine visitor use with the new extension and address the question of limited use of the estuary trail.

In the absence of data on why visitors did not travel the length of the trail, I recommend vegetation restoration in the vicinity of the HMSC water storage facility, continuing along the north side of the trail until sign 5. Throughout this section of the trail, HMSC buildings and parking areas are clearly visible, detracting from the "nature trail" feeling. Vegetation restoration in this area



may contribute to visitors enjoyment of their experience and may encourage full use of the trail.

If the HMSC were to continue the estuary naturalist programs, establish a self-guided beach walk, and restore vegetation in the areas where buildings are adjacent to the trail, I believe the estuary educational programs would meet with even greater success than has been determined by this study.

## REFERENCES CITED

- American Association of Museums. *Museums Count*. Data Report from the 1989 National Museum Survey. Washington D.C.
- Alt, M.B. 1980. Four years of visitor surveys at the British Museum (Natural History) 1976-79. *Museums Journal* 80: 10-19.
- Baron, J.B. and K. Hogan. 1988. Fostering and evaluating thinking skills in the informal science setting. pp. 21-44 In, P.G. Helton and L.A. Marquardt eds. *Science Learning in the Informal Setting*. Chicago Academy of Sciences.
- Birney, C. 1992. Personal communication. American Association of Museums Annual Meeting. Baltimore, Maryland.
- Borun, M. 1990. Naive notions and the design of science museum exhibits. pp. 1-3 In, B. Serrell (ed) *What Research Says About Learning in Science Museums*. Association of Science-Technology Centers.
- Borun, M. 1977. *Measuring the Immeasurable: A Pilot Study of Museum Effectiveness*. Washington D.C.: Association of Science-Technology Centers.
- Borun, M. and M. Miller. 1979. *What's in a Name? A Study of the Effectiveness of Explanatory Labels in a Science Museum*. Washington D.C.: Association of Science-Technology Centers.
- Cable, T.T., D.M. Knudson, E. Uddy, and D.J. Stewart. 1987. Attitude change as a result of exposure to interpretive messages. *Journal of Park and Recreation Administration*, 5,1: 47-59.
- Cohen, M.R. 1973. Environmental information versus environmental attitudes. *Journal of Environmental Education*, 5: 5-8.
- Csikszentmihalyi, M. 1988. Human behavior and the science center. pp. 80-87 In, P.G. Helton and L.A. Marguardt (eds) *Science Learning in the Informal Setting*. Chicago Academy of Sciences.
- DeMouthe, J. 1989. *Visitor Behavior as a Measure of the Educational Effectiveness of Museum Exhibits*. PHD. dissertation, University of California, Berkeley.

- DeWaard, R.J., N. Jagmin, S.A. Maisto, and P.A. McNamara. 1974. Effects of using programmed cards on learning in a museum environment. *Journal of Educational Research* 67: 457-460.
- Dowell, D.L. and S.F. McCool. 1986. Evaluation of a wilderness information dissemination program. pp. 494-500 In, R.C. Lucas (compiler) *Proceedings, National Wilderness Research Conference: Current Research*. (USDA Forest Service General Technical Report INT-212) Ogden UT: Intermountain Research Station.
- Eason P. and M.C. Linn. 1975. Evaluation of the effectiveness of participatory exhibits. *Curator*, 19: 45-62.
- Falk, J.H. 1983. Time and behavior as predictors of learning. *Science Education*, 67: 267-276.
- Falk, J.H. 1982. The use of time as a measure of visitor behavior and exhibit effectiveness. *Museum Roundtable Reports: The Journal of Museum Education*, 7: 22-28.
- Falk, J.H. and J.D. Balling. 1982. The field trip milieu: Learning and behavior as a function of contextual events. *Journal of Educational Research*, 76: 22-28.
- Falk J.H., J.J. Koran, and L.D. Dierking. 1986. The things of science: Assessing the learning potential of science museums. *Science Education*, 70: 503-508.
- Fortner, R.W. and A.E. Lyon. 1984. Effects of a Cousteau television special on viewer knowledge and attitudes. *Journal of Environmental Education*, 16,3: 12-20.
- Fortner R.W. and V.J. Mayer. 1983. Ohio students knowledge and attitude about the oceans and Great Lakes. *Ohio Journal of Science*, 83: 218-224.
- Fortner, R.W. and T.G. Teates. 1980. Baseline studies for marine education: Experience related to marine knowledge and attitudes. *Journal of Environmental Education*, 11: 11-19.
- Fronville, C.L. and Z.D. Doering. 1989. *Visitor Perspectives on Tropical Rainforests*. A report based on the 1988 "Tropical Rainforests: A Disappearing Treasure" information study. Institutional Studies, Smithsonian Institution.

- George, R.W. 1967. A comparative analysis of conservation attitudes where conservation education is a part of the educational experience. *Transactions of North American Wildlife*, 32: 199-211.
- Gottfried, J.L. 1979. *A Naturalistic Study of Childrens Behavior During Field Trips to a Free-Choice Learning Environment*. PhD Dissertation, University of California, Berkeley.
- Griggs, S.A. 1983. Orienting visitors within a thematic display. *International Journal of Museum Management and Curatorship*, 2: 119-134.
- Griggs, S.A. and M.B. Alt. 1982. Visitors to the British Museum (Natural History) in 1980 and 1981. *Museums Journal*, 82: 149-155.
- Hammitt, W.E. 1984. Cognitive processes involved in environmental interpretation. *Journal of Environmental Education*, 15,4: 11-15.
- Hoover, H.H. and R.E. Schutz. 1963. Conservation attitudes of science majors as compared with those of non-science majors. *Journal of Research in Science Teaching* 2: 108-110.
- Hounshell, P.B. and L. Liggett. 1973. Assessing the effectiveness of environmental education. *Journal of Environmental Education*, 5: 28-30.
- Kellert, S.R. and J. Dunlap. 1989. *Informal Learning at the Zoo: A Study of Attitude and Knowledge Impacts*. A Report to the Zoological Society of Philadelphia.
- Kiely-Brocato, K. 1980. An assessment of visitor attitudes toward resource use and management. *Journal of Environmental Education*, 11: 29-36.
- Koran, J.J.Jr., S.J. Longino, and L.D. Shafer. 1983. A framework for conceptualizing research in natural history museums and science centers. *Journal of Research in Science Teaching*, 20: 325-339.
- Laetsch, W.M., J. Diamond, J.L. Gottfried, and S. Rosenfeld. 1980. Children and family groups in science centers. *Science and Children*, 17: 14-17.
- Lucas, A.M. 1983. Scientific literacy and informal learning. *Studies in Science Education*, 10: 1-36.

- Mahaffey, B.D. 1969. Effectiveness and preference for selected interpretive media. pp 180-183 In, Clay Shoenfeld (ed) *Interpreting Environmental Issues*.
- Maloney, M.P., M.P. Ward, and G.N. Braucht. 1975. A revised scale for the measurement of ecological attitudes and knowledge. *American Psychologist*, 30: 787-790.
- Maloney, M.P. and M.P. Ward. 1973. Ecology: let's hear it from the people. *American Psychologist*, 28: 583-586.
- Massey, W.E. 1988. Science for all citizens: Setting the stage for life-long learning. pp. 133-143 In, P.G. Helton and L.A. Maraquardt (eds) *Science Learning in the Informal Setting*. Chicago Academy of Sciences.
- McManus P.M. 1987. It's the company you keep. . . The social determination of learning-related behavior in a science museum. *International Journal of Museum Management and Curatorship*, 6:263-270.
- Miles, R.S. and A. Tout. 1979. Outline of a technology for effective Science Exhibits. *Special Papers in Paleontology*, 22: 209-224.
- Miller, J.D. 1988. The roots of science literacy: The role of informal learning. pp. 171-182 In, P.G. Helton and L.A. Maraquardt (eds) *Science Learning in the Informal Setting*. Chicago Academy of Sciences.
- Millward, R.E. 1975. An appraisal of present attitudinal environmental programs and a prediction of future evaluative trends. In, B. van der Smissen (compiler) *Research Camping and Environmental Education*. The Pennsylvania State University.
- Nielsen, C. and T. Buchanan. 1986. A comparison of the effectiveness of two interpretive programs regarding fire ecology and fire management. *Journal of Interpretation*, 11: 1-10.
- Olson, E.C., M.L. Bowman and R.E. Roth. 1984. Interpretation and nonformal environmental education in natural resources management. *Journal of Environmental Education*, 15,4: 6-10.
- Oregon State University Mark O. Hatfield Marine Science Center. 1991. *Institute of Museum Services General Operating Support Grant Proposal*. Newport, OR: Mark O. Hatfield Marine Science Center.

- Parsons, L.A. 1968. Systematic testing of display techniques for an anthropological exhibit. In, S.F. Borhegyi and I. Hanson (eds) *The Museum Visitor, Publications in Museology-3*. Milwaukee Public Museum, Milwaukee.
- Peart, R. 1984. Impact of exhibit type on knowledge gain, attitudes, and behavior. *Curator*, 27: 220-237.
- Richmond, J.M. 1976. *A Survey of Environmental Knowledge and Attitude of Fifth Year Students in England*. Doctoral dissertation. The Ohio State University.
- Roggenbuck, J.W. and J. Passineau. 1986. Use of the field experiment to assess the effectiveness of interpretation. pp. 65-86 In, B. McDonald Cordell (ed) *Proceedings, Southeastern Recreation Research Conference*. Recreation Technical Assistance Office, Institute of Community and Area Development. Athens, GA: University of Georgia.
- Rokeach, M. 1975. *Beliefs, Attitudes and Values*. Jossey-Bass Publications. San Francisco.
- Rosenfeld, S. 1980. *Informal Learning in Zoos: Naturalistic Studies of Family Groups*. PhD. dissertation, University of California, Berkeley.
- Sakoffs, M. 1984. Interpretive programming: Opportunities to promote political action. *Journal of Environmental Education*, 15: 38-39.
- Screven, C.G. 1988. Teaching science to voluntary learners and the role of evaluation. pp. 230-240 In, P.G. Helton and L.A. Maraquardt (eds) *Science Learning in the Informal Setting*. Symposium proceedings. Chicago Academy of Sciences.
- Screven, C.G. 1986. Exhibitions and information centers: some principles and approaches. *Curator*, 29: 109-138.
- Screven, C.G. 1976. Exhibit evaluation-a goal-referenced approach. *Curator*, 19: 271-290.
- Screven, C.G. 1975. The effectiveness of guidance devices on visitor learning. *Curator*, 18: 218-243.
- Screven, C.G. 1968. The application of programmed learning and teaching systems procedures for instruction in a museum environment. *The Museum Visitor, Publications in Museology-3* Milwaukee Public Museum, pp. 167-174.

- Serrell, B. 1992. The 51% solution: Defining a successful exhibit by visitor behavior. *Current Trends in Audience Research and Evaluation*, 6: 26-30.
- Shen, B.S.P. 1975. Science literacy and the public understanding of science. pp. 44-52 In, S.B. Day (ed) *Communication of Scientific Information*. S. Karger publications Basel.
- Sheppard, D. 1960. Methods of Assessing the Value of Exhibitions. *British Journal of Educational Psychology*, 30: 259-265.
- Sheppard, C.L. and L.R. Speelman. 1986. Affecting environmental attitudes through outdoor education. *Journal of Environmental Education*, 17: 20-23.
- Shettel, H.H. 1992. Personal communication. American Association of Museums Annual Meeting. Baltimore, Maryland.
- Shettel, H.H., M. Butcher, T.S. Cotton, J. Horthrup, and D.C. Slough. 1968. *Strategies for Determining Exhibit Effectiveness*. Pittsburgh: American Institutes for Research (AIR-E95-4/68-FR).
- Stronck, D.R. 1983. The comparative effects of different museum tours on children's attitudes and learning. *Journal of Research in Science Teaching*, 20: 283-290.
- Tissot, S.G. 1991. Visitor behavior at the Mark O. Hatfield Marine Science Center Aquarium. pp. 57-111 In, R. Hall (ed) *Planning for Tourists: Contributions of Museums*. Anthropology Northwest: Number 7. Oregon State University, Corvallis Oregon.
- Webb, E., D. Campbell, R. Schwartz and L. Sechrest. 1966. *Unobtrusive Measures: Nonreactive Research in the Social Sciences*. Rand McNally Publishing Co., Chicago.
- Weber, L.J. 1993. Personal communication. Mark O. Hatfield Marine Science Center. Oregon State University, Corvallis, Oregon.
- Weisberg, H.F. and B.D. Bowen. 1977. *An introduction to survey research and data analysis*. W.H. Freeman and Co. San Francisco.
- Westphal, J.M. and W.F. Halverson. 1985. Assessing the long-term effects of an environmental education program: A pragmatic approach. *Journal of Environmental Education*, 17,2: 26-30.

- Wittlin. 1968. Exhibits, interpretive, under-interpretive, misinterpretive. Absolutes and relative absolutes in exhibit techniques. pp. 95-113 In, E. Larrabee (ed) *Museums and Education*. Smithsonian Institution Press. Washington D.C.
- Wittrock, M.C. 1979. The cognitive movement in psychology. *Educational Research*, 8: 5-11.
- Wright, E.L. 1980. Analysis of the effect of a museum experience on the biology achievement of sixth-graders. *Journal of Research in Science Teaching*, 17: 99-104.



## APPENDICES

## Appendix I

Hatfield Marine Science Center Estuary Trail  
Education Study Questionnaire

**Thank you for participating in the Hatfield Marine Science Center Estuary Trail study. This questionnaire has been designed to take approximately 5 minutes.**

**Have you been to the Marine Science Center before this visit?**

- 1 yes  
2 no

**The following group of statements focuses on the natural history and ecology of estuaries. Please indicate if you think each statement is TRUE, FALSE, or if you are NOT SURE by circling ONE number.**

|  | TRUE | FALSE | NOT<br>SURE |
|--|------|-------|-------------|
| An estuary is defined as a place where fresh and salt water meet. .... 1                                   |      | 2     | 3           |
| Estuaries are important nursery areas for marine fish. .... 1  |      | 2     | 3           |
| Most of the aquatic birds in Yaquina Estuary are year round residents. ... 1                               |      | 2     | 3           |
| Mudflats, saltmarshes and eelgrass beds in the estuary are all wetland habitats. .... 1                    |      | 2     | 3           |
| Herring spawn in eelgrass beds in Yaquina Estuary. .... 1  |      | 2     | 3           |
| Living in an estuary will not protect organisms from ocean waves. .... 1                                   |      | 2     | 3           |
| A salt water wedge is formed in the estuary due to temperature differences of salt and fresh water. .... 1 |      | 2     | 3           |
| Eelgrass is an important food for geese. .... 1  |      | 2     | 3           |
| Living in an estuary can be stressful to animals and plants because currents are fast. .... 1              |      | 2     | 3           |
| The biological productivity of a mudflat is very low. .... 1   |      | 2     | 3           |
| Detritus is a group of tiny animals and plants. .... 1   |      | 2     | 3           |
| One of the stresses animals and plants in an estuary must adapt to is changes in salinity. .... 1          |      | 2     | 3           |
| A saltmarsh indicator is a type of mud found below the marsh. .... 1                                       |      | 2     | 3           |
| The ghost shrimp creates burrows in the mudflats that clams and worms live in. .... 1                      |      | 2     | 3           |

|   | TRUE | FALSE | NOT<br>SURE |
|---|------|-------|-------------|
| Colonizing salt marsh plants collect sand and mud and build up the marsh. .... 1                                |      | 2     | 3           |
| One of the reasons plant and animal productivity is high in estuaries is that rivers bring in nutrients. .... 1 |      | 2     | 3           |
| Diatoms are very important because they are part of the base of the estuarine food web. .... 1                  |      | 2     | 3           |
| The brown color of the mudflats is due to diatoms. .... 1   |      | 2     | 3           |
| A willow can tolerate high salinity. .... 1   |      | 2     | 3           |
| Organisms in estuaries are not adapted for living with tidal changes. .... 1                                    |      | 2     | 3           |
| Juvenile salmon may spend months in the estuary before going to sea. ... 1                                      |      | 2     | 3           |
| Cormorants are birds that dive over 100 feet deep to catch fish. .... 1   |      | 2     | 3           |
| One of the ways a salt marsh plant adapts to salinity is to fill its cells with saltwater. .... 1               |      | 2     | 3           |

Below is a list of statements that have been made about the uses of wetlands and estuaries. Please indicate how strongly you agree or disagree with each one. (Circle ONE number for each statement).

|   | Strongly<br>Agree | Agree | Neither<br>Agree nor<br>Disagree | Disagree | Strongly<br>Disagree |
|---|-------------------|-------|----------------------------------|----------|----------------------|
| If an individual has a wetland on his/her property, he/she should be able to fill or drain it without a permit. ....1     | 2                 | 3     | 4                                | 5        |                      |
| Most estuaries have areas that should be dredged to make extra room for boat docks. ... 1                                 | 2                 | 3     | 4                                | 5        |                      |
| The responsibility for preserving wetlands should be that of private organizations only, not the government. ....1        | 2                 | 3     | 4                                | 5        |                      |
| Businesses should be required to get a permit before filling or draining a wetland. ... 1                                 | 2                 | 3     | 4                                | 5        |                      |
| Mudflats and saltmarshes should not be filled in for new housing development. .... 1                                      | 2                 | 3     | 4                                | 5        |                      |
| Wetlands provide important habitat for fish and wildlife as well as performing many valuable functions for society. ....1 | 2                 | 3     | 4                                | 5        |                      |
| Filling in land for agriculture is more important than preserving estuaries. .... 1                                       | 2                 | 3     | 4                                | 5        |                      |
| The proposed change in the wetlands definition will free needed lands for development. ....1                              | 2                 | 3     | 4                                | 5        |                      |
| A community should be able to fill or dredge an estuary for;  |                   |       |                                  |          |                      |
| housing. ....1  | 2                 | 3     | 4                                | 5        |                      |
| agriculture. .... 1   | 2                 | 3     | 4                                | 5        |                      |
| hotels and convention centers .... 1  | 2                 | 3     | 4                                | 5        |                      |
| industrial site ....1   | 2                 | 3     | 4                                | 5        |                      |
| A class in environmental studies should be required in elementary or high school. .... 1                                  | 2                 | 3     | 4                                | 5        |                      |

From what you know or have heard, are there any wetland controversies in your community?

- 1 yes
- 2 no

Finally, we ask a few questions about you to help us interpret our results.

Are you:

- 1 Female
- 2 Male

Have you been on this estuary trail before?

- 1 yes
- 2 no

Have you visited any other estuary trail before?

- 1 yes
- 2 no

Do you live within ten miles of a wetland?

- 1 yes
- 2 no
- 3 not sure

What is the level of education you have completed?

- 1 grade school
- 2 some high school
- 3 high school graduate
- 4 some college
- 5 college graduate; major \_\_\_\_\_
- 6 graduate school or other post college education; area of study \_\_\_\_\_

Which is your age group?

- 1 18-27
- 2 28-37
- 3 38-47
- 4 48-57
- 6 58-67
- 7 68 +

Are you currently, or have you ever been, a member of a conservation organization?

- 1 yes
- 2 no

What is your zip code? \_\_\_\_\_

What, if any, do you think is the biggest environmental concern facing our country today?

-----

## The Yaquina Estuary and its Inhabitants.



### What is an estuary?

#### A place where fresh and salt water meet.

An estuary is a place where fresh and salt water meet. Here in Yaquina Bay high tide brings salt water from the ocean twice a day. The salt water mixes with fresh water flowing down the Yaquina River.

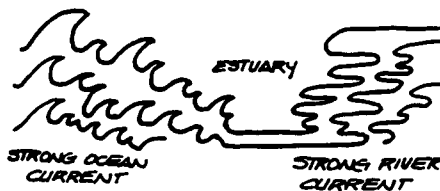
#### A place that provides shelter.

A haven from crashing sea waves and turbulent river currents, an estuary is a relatively calm environment that can shelter organisms from powerful water movements.

#### A place of change.

Salinity, the amount of salt in the water, changes daily in the estuary. High tide increases salinity; low tide allows fresh water to flow further into the bay. Salinity is highest near the mouth, the opening to the sea, and lowest at the head of tidewater.

Daily tides also bring changes in water level. While some areas are always under water, tidal fluctuations leave many habitats exposed to air for varying lengths of time. These are called intertidal areas.



## Who lives in the estuary?

2

Shorebirds, waterfowl, clams, shrimp, and fish, are some of the many animals that live in the Yaquina estuary. Each may be found here for all or some critical part of their life, taking advantage of the high productivity and the shelter provided by this environment.

Animals and plants that live in the estuary are uniquely adapted, or suited, to life in an environment where changes in salinity and water level occur with every tide. Some marine fish respond to salinity fluctuations by leaving the upper estuary when salinity is low. Clams close their shells tightly at low tide or during extreme fresh water runoff, protecting themselves both from drying out and from fresh water, toxic to their cells.

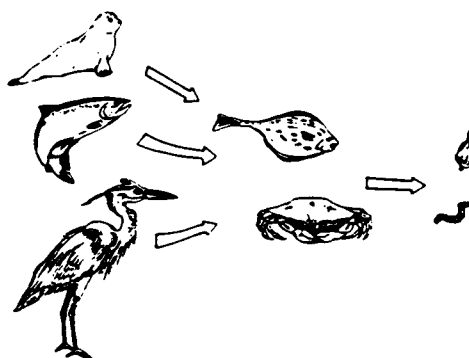
## How Productive is the Estuary?

The supply of nutrients from the river and the ocean, the abundance of detritus, or dead organic matter, and the constant mixing that occurs in the estuary all contribute to these environments being among the most biologically productive places on earth.

### Detritus and the estuarine food web.

Inorganic materials dissolved in the water are used by estuarine plants for their growth.

Although animals eat some of the vegetation, most of it eventually dies. Bacteria break down the plant matter into bits and pieces, and tides and currents carry it about. This material is called detritus.



As the Yaquina River flows into the estuary it slows and begins to drop its load of nutrients and decaying plant and animal matter. This "rain" of organic material is another source of detritus for the estuary.

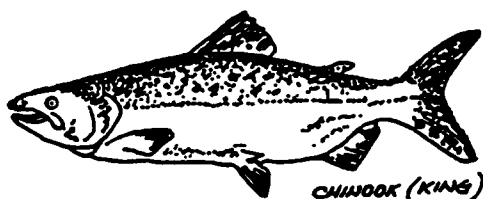
Detritus is a nutritious food for numerous animals such as clams, worms, and young fish. They, in turn, may be eaten by larger fish, seals, or birds in a complex food web that also includes humans.

**How many different habitats are found in the estuary?** 3

Within an estuary there are four recognized habitats; open water, eelgrass beds, mudflats, and salt marshes.

#### **Open Water Habitat.**

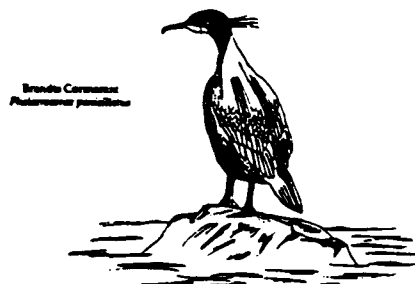
Never exposed by the tides, the open water is a deepwater habitat. Fish, seals, sea lions, and occasionally whales move into this habitat from the ocean seeking food and shelter from predators.



Chinook  
*Oncorhynchus tshawytscha*

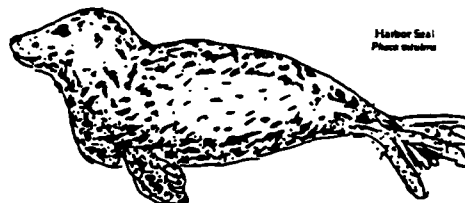
Chinook and Coho salmon migrate through the open water habitat and into the Yaquina River and its tributaries to spawn. Juveniles return through the open water to marsh creeks where they feed and seek shelter from predators. Salmon may spend up to a few months in the estuary before moving to the ocean.

Cormorants and other diving birds may be seen on the surface of the open water habitat. In the open ocean cormorants can dive well over 100 feet in search of small fish prey. Whether in the estuary or the ocean, these marine birds use their feet to propel themselves underwater.



Brandt's Cormorant  
*Phalacrocorax penicillatus*

Harbor seals are often seen in estuaries, either resting along the shore or feeding in the open water habitat. Food for this marine mammal can include salmon, herring, and starry flounder.



Harbor Seal  
*Phoca vitulina*



### Eelgrass Bed Habitat.

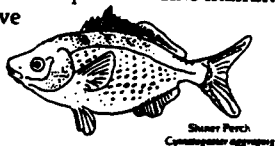
4

Adjacent to the open water habitat are the eelgrass beds, a wetland habitat that is exposed only by the lowest tides. Eelgrass forms dense underwater meadows; nurseries that provide shelter and food to many juvenile fish and shellfish.

Dungeness crabs hatch in the ocean and move to shallow water and estuaries at about 3 months. Feeding on clams and small crustaceans, many juveniles in Yaquina estuary hide from predators in dense eelgrass beds. As they grow older dungeness crabs return to deep water, yet each spring some adults move to nearshore and estuarine habitats to feed.

Pacific herring enter the Yaquina estuary each February to spawn. Females produce up to 30,000 sticky eggs that adhere to eelgrass, seaweed and rocks. Many birds including scaups, scoters, gulls, and coots feed on herring eggs. The eggs hatch in 10 days and the estuary becomes a nursery for the young herring who remain there through the fall, feeding and hiding from predators.

Shiner perch are viviparous. Like mammals, the females give birth to live young who receive nourishment from



Shiner Perch  
*Cymatogaster aggregata*

their mother before birth. Eelgrass beds are important nursery areas for these fish who are most abundant in this habitat from May through October, the time when juveniles are most likely to be found.

Bay pipefish are well camouflaged in eelgrass beds where they spend much of their lives. The breeding season for pipefish begins in February, and it is the male that carries the eggs in a brood pouch on his underside.



Brant  
*Branta ferula*

The Brant is a small goose that winters in the Yaquina estuary. Eelgrass constitutes about 80% of the diet of these birds. Dredging and other human activities have reduced the amount of eelgrass in west coast estuaries, and healthy Brant populations depend on the preservation of remaining eelgrass beds.

## Mudflat Habitat.

5

At low tide you will see the expansive mudflats adjacent to the Marine Science Center. Appearing barren and desolate from a distance, a close up view of a mudflat reveals the myriad of organisms such as **shrimp, clams, crabs, and worms** that make a home in this wetland habitat. The brown color on the mudflat surface is a coating of diatoms, tiny plants that together with detritus make up the basis of the estuarine food web.

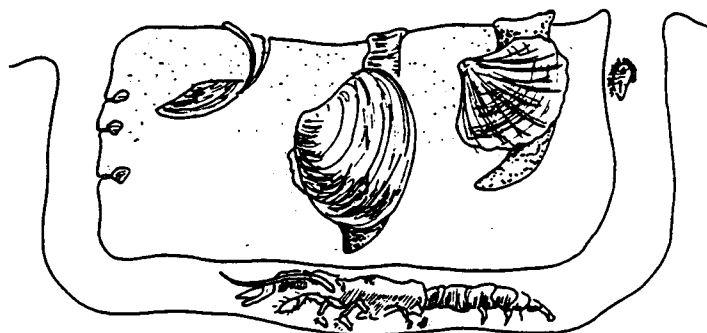
The **ghost shrimp**, an industrious excavator, lives in a burrow it digs in the sediment. The ghost shrimp is a deposit feeder; it swallows sediments and digests the thick coat of bacteria that colonizes mud particles. **Worms, pea crabs and clams** take advantage of the shrimp's hard work and live in the burrow. The free-loaders benefit by feeding on the shrimp's leftovers or filtering plankton and detritus from the water.

Many of Oregon's clam species live in the sheltered environment of the estuary. Extending their fleshy siphons to the surface, most clams feed

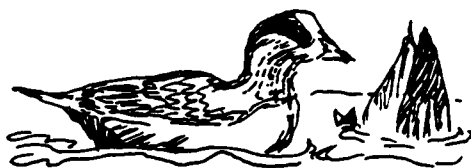
by filtering plankton and detritus when the tide is high. The mudflat is home to many including **gapers, littlenecks, and softshells**.

The **bent-nose clam** is a deposit feeder that uses its siphon like a vacuum cleaner to suck in sediments from the surface of the mudflat. While clams come in many sizes, we can determine the age of some by counting growth rings on the shell, much the same as counting rings on a tree.

When the tide is high fish such as **starry flounder** and **sanddabs** migrate over the mudflats from nearby habitats to feed. The opportunity for dinner is not lost on **Great Blue Herons** that can be seen wading on the mudflats in search of fish. The successful heron pierces its prey with the tip of its long sharp bill.



In the past, vast areas of mudflat habitat were covered by the material from dredging activities. The remaining mudflats are under pressure for development in many estuaries around the globe.



American Widgeon  
*Mareca americana*

#### Birds of the Open Water, Eelgrass Bed, and Mudflat Habitats. 6

Most of the aquatic birds in the estuary are seasonal visitors, either spring and fall migrants or wintering individuals.

Millions of birds migrate annually along the Pacific coast, flying from Arctic breeding grounds to wintering areas in the south. Calm protected estuaries and other wetlands provide vital rest stops, and the highly productive estuaries supply many birds with the food they need to spend the winter or continue their journey.

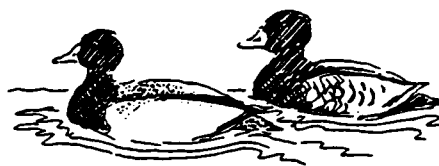
At low tide, look over the mudflats for shorebirds such as sandpipers, whimbrels and dunlin. The size and shape of a bird's bill gives clues as to the type of food it eats. A sandpiper uses its short bill to collect animals on or just below the surface,



finding its prey by sight. The whimbrel uses its long curved highly sensitive bill to probe deep into the mud for shrimp and worms.

Waterfowl may be seen on the surface of any submerged habitat in the estuary. While swans are rare in the Yaquina estuary, ducks and geese commonly occur from September through May.

Lesser scaup are diving ducks that are found in the Yaquina estuary from September through May. Their bills are specialized for straining small crustaceans and other invertebrates from the water.



Lesser Scaup  
*Aythya affinis*

Other ducks like the American widgeon are dabblers. A dabbler feeds by tipping forward and submerging its head and neck to reach for underwater food, generally plants and small invertebrates.

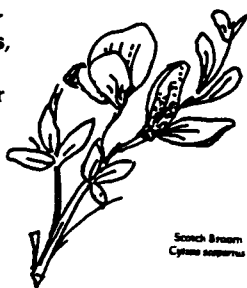
## Upland Habitat.

7

A habitat that is next to the estuary, the uplands begin where the highest high tide of the year stops. While spring and summer are the best time to see flowers along the estuary trail, many of the perennial plants are easily identified throughout the year.

Some of the plants here are native, having arrived to this area before the first Euroamericans, yet many are not. Introductions such as the European beach grass, were planted to stabilize dunes or shifting sand. Others like the Scotch broom were planted as ornamentals. Non-native or exotic plants often have the ability to outcompete and displace the native ones in an area, a process that can eventually lead to a local decrease in species diversity.

Yarrow, can be seen all along the trail, blooming from June through September. Native Americans used this aromatic plant as a tea and stong solutions were used medicinally.



Scotch Broom  
*Cytisus scoparius*

Yellow lupine, introduced from northern California, has bacteria in its roots that convert nitrogen from the atmosphere to a form the plant can use. A member of the pea family, lupine does well in the low nitrogen soils of the Pacific Northwest.



Lupine  
*Lupinus albus*

Like most upland plants, willow cannot tolerate highly saline soils. The bark of this tree was chewed by Native Americans to relieve headaches. Today salicylic acid, a primary component in modern day aspirin, is extracted from the willow.



Willow  
*Salix hookeriana*

## Salt Marsh Habitat.

8

The salt marsh is a wetland habitat that lies in protected areas along the fringes of the estuary, above the mudflats and below the uplands.

Salt marshes are created by plants that colonize high points on the mudflat. The first to take hold are pickleweed and salt grass. As



Pickleweed  
*Sarcocornia virginica*

these aggressive colonizers begin to grow, they slow down currents and trap sediment, building the marsh up and out towards the bay.

The forward edge of the salt marsh is called the low marsh. This area is

flooded twice each day with the high tides. Plants in this zone differ from those found in the high marsh, the region that may be flooded only by the highest tides that occur a few days out of each month.

### Marsh plant adaptations

Salt water is toxic to most flowering plants, causing fresh water to move out of their cells and dissolved salts to move in. Those plants that survive in the saltmarsh do so only with special adaptations. One common adaptation is succulence, dealing with high salinity by dilution. A bite into the fleshy stem of the

pickleweed will reveal the salty water that is stored in its stems.



### Marsh animals.

Because daily tides expose the salt marsh to the air, aquatic animals are not common. Those that do occur usually migrate in and out with the tides. Pacific staghorn sculpin, shiner perch, and juvenile salmon swim up into salt marsh creeks and pools at high tide to feed and hide from predators.

Shorebirds rest in the saltmarsh and the grassy shore when high tide covers the mudflats. They feed on invertebrates in the low marsh. Kingfishers are diving birds that can be seen feeding on small fish in salt marsh creeks at high tide.

## The estuary.

9

An estuary is defined as a place where fresh and salt water meet. It is a calm protected environment where animals seek shelter and food. An estuary is also a place of change. Organisms that live there must be capable of adapting to the ever-changing conditions.

Some inhabitants are well suited to year round life within one of the four estuarine habitats. Others spend only a portion of their lives there, using the estuary as a nursery, migration stopover, or place to feed.

Many of Oregon's estuarine habitats have been altered due to human activities. Few natural salt marshes remain in the Yaquina estuary, and pressure to continue dredging and filling threatens many estuaries in Oregon, and around the world. Preservation of remaining estuarine habitats is vital for the survival of many organisms that are dependent on these highly productive environments.



Appendix III

Hatfield Marine Science Center Estuary Trail:  
A Manual for Naturalists

THE HATFIELD MARINE SCIENCE CENTER ESTUARY TRAIL  
A MANUAL FOR NATURALISTS

## INTRODUCTION

An estuary is the ecosystem where fresh and salt water meet. Estuaries are defined as semi-enclosed bodies of water connected to the ocean where the salt water is measurably diluted by freshwater. Estuaries are the transition between freshwater and marine ecosystems. In Yaquina Bay the Yaquina river flows into the bay bringing fresh water from the mountains. This fresh water mixes with ocean water coming in through the mouth of the bay, forming the Yaquina estuary.

Estuaries are most common in areas where there is a low, flat shoreline, such as the east coast. West coast estuaries are less common, and, as a whole, are smaller than their east coast counterparts.

There are four types of estuaries; drowned river mouths, fjords, deltas, and bar-built estuaries. Of the four types, the Yaquina estuary is a drowned river mouth. Over ten thousand years ago the sea level was much lower than it is today. The shoreline was 30-40 miles west of where it is now and it dropped off steeply onto the continental shelf. At that time the river flowed directly into the sea. As the climate changed, polar glaciers began melting and the sea level began to rise, flooding the river valley and forming the Yaquina estuary.

An estuarine ecosystem is dynamic, the water level, temperature, and salinity are constantly in a state of flux.



Twice daily, high tide brings salt water, nutrients and organic material from the ocean into the bay. The Yaquina River also flows into the estuary bringing nutrients and organic material down from the Coast Range into the bay.

Daily water level fluctuations in the estuary are due to the ebb and flow of the tides. The tides on the Pacific coast of North America have a mixed diurnal cycle meaning that each day there are two high and two low tides of unequal heights. The tides are driven by the gravitational force of the moon; the tide cycle follows a lunar day, every 24 hours and 50 minutes, not every 24 hours as in sun days. This is why the high and low tides are at different times each day. Due to the tides, there are some habitats in the estuary, such as mud flats, that are submerged under water or exposed to the air twice each day. Other habitats like salt marshes, are submerged occasionally, and others such as eelgrass beds are rarely exposed to the air.

When salt and fresh water meet, as in an estuarine environment, there are a few processes that may occur. In some estuaries, the lighter, less dense fresh water will float on top of the salt water forming a salt water wedge. In most of Oregon's estuaries the region where salt and fresh water meet is a zone of mixing. The upstream end of the zone blends into fresh water; the downstream end blends into salt water.

The location of the zone of mixing changes in the

estuary depending upon the tides and the season. When the tide is high, salt water is drawn far up the bay. In the Yaquina Estuary, relatively high salinity may extend as far as the town of Toledo. When the tide is low, the estuary is dominated by fresh water flowing from the Yaquina River. During this time high salinity is restricted to the region near the opening to the bay, and fresh water fills the estuary.

In the winter or spring when rainfall is high and the river is full, water coming down from the mountains flows far out into the bay. This fresh water influx lowers the salinity levels; even during a high tide fresh water may extend far into the estuary. In the summer and fall, when rainfall is minimal and the rivers are low, salt water extends further up the estuary and salinity is higher.

The temperature fluxes evident in an estuary are also closely tied to the tides and the seasons. When the tide is high the cool water of the ocean covers the mud flats and often the salt marshes in the estuary, keeping the temperature low. When the tide goes out and these habitats are exposed, the temperature increases.

In the winter, the temperature of the water is warmer near the mouth of the bay, where the ocean temperatures moderate against colder inland conditions. In the summer the reverse occurs. While temperatures can be very high at the upper end of the estuary because the river is warm, the

mouth of the bay may be cooler due to the late spring upwelling of oceanic water. This upwelling brings cold water from the ocean depths to the surface. The cold water flows in through the mouth of the bay, cooling the water at the lower end of the estuary.

An estuary is a dynamic environment. The fluctuation of fresh and salt water in and out of the ecosystem create an environment which is extremely rich in minerals and nutrients, yet is stressful for organisms to live in. Many organisms are dependent upon estuarine environments during some part of their life history and are well adapted to live in such a dynamic place. The dynamic processes that characterize estuaries contribute to their being among the most productive environments on the planet.

## THE PRODUCTIVITY OF ESTUARIES

### **The estuarine food web:**

The term "primary productivity" refers to the amount of material produced by plants in a system. In an estuary, the primary producers include phytoplankton, sea grasses such as eelgrass, and salt marsh plants. In many habitats it is the primary producers, the base of the food web, that fuel the rest of the organisms. The food web in the Yaquina estuary is also driven by "detritus", or dead organic material. When plants and animals in the estuary die, bacteria and fungi settle on them and begin to break them down into smaller and smaller pieces. These pieces of organic material settle onto the bottom, or drift through the water.

Many animals in the estuary feed on detritus. Some of these "detritivores" include worms, small shrimps, amphipods, and isopods, many of whom crawl along the bottom. The clam *Macoma* is a detritivore that uses its siphon to vacuum detritus from the sand and mud. Other detritivores such as clams and cockles use their siphons to filter detritus from the water.

### **Estuarine Productivity:**

Estuaries are highly productive ecosystems. Similar to a farm where crop production varies depending on the soil, nutrients, and water, productivity in natural environments varies. Estuaries are among the most productive ecosystems on the planet.

One reason estuaries are highly productive is their location between marine and freshwater systems. Here in Newport the Yaquina River flowing into the bay brings organic material and nutrients from far in the mountains. As the river flows into the estuary it spreads out and covers the mud flats and salt marshes. As it slows, the river water begins to drop its load. This "rain" of organic material is an important source of nutrients for the organisms in the estuary, and contributes to the high productivity of these ecosystems.

Twice a day incoming tides also affect the nutrient levels in the estuary. The tides draw in organic matter and nutrients from the ocean. These materials are also dropped out into the habitats of the estuary. When the tide ebbs, it takes with it the wastes generated in the estuary, flushing out the system.

Estuaries are shallow, which also contributes to their productivity. In the ocean, as organic material is broken down, much of it drifts to the bottom of the sea and is no longer available to organisms living in shallow regions. Estuaries are generally shallow, when the detritus settles to the bottom, it is still available to many organisms. The shallow depth also means that light can penetrate to most areas. This leads to a high potential rate of photosynthesis, the process whereby plants convert sunlight, carbon dioxide and nutrients into food.

The mixing that occurs in estuarine environments also adds to the high productivity. Commonly referred to as "mixing bowls", the wind, storm waves, currents, tides, and river flow, all act to keep estuaries constantly stirred up. Since most of detritus that is broken down by bacteria and fungi is in the sediments, and mixing keeps the sediments stirred up, the detritus is constantly available to organisms for food. The combination of plankton, detritus and nutrients in the estuary is sometimes referred to as "estuarine soup", and is a vital part of the productivity of these environments.

Together, all of these processes mean that estuaries are efficient at producing organic material, and at recycling, and therefore are highly productive systems.

## **ESTUARINE HABITATS**

There are four habitats in a estuary: Open Water, Eelgrass Beds, Tide Flats, and Salt Marshes. Each habitat contains organisms uniquely adapted to live in that environment. A fifth habitat, the Uplands, is the terrestrial (land) area immediately adjacent to the estuary.

### **Open water**

The open water habitat is the deepest part of the estuary, the region that is never exposed by the tides. The open water is an important channel for fish, such as salmon and herring, to migrate through from the ocean. While herring remain in the estuary to spawn, salmon continue upstream to their spawning grounds. Many waterfowl use the open water habitat to feed on fish and invertebrates. Marine mammals such as seals and sea lions will also come into the estuary through the open water habitat and feed on fish or invertebrates. Orcas may be seen in this habitat in the spring feeding on the sea lions.

### **Eelgrass Beds**

The eelgrass beds are the transition zone between the open water and the mud flats. Eelgrass beds, like a forest, provide shelter and food for an abundance of organisms. Dense growths of eelgrass can reduce the velocity of currents and trap dissolved organic material. Consequently, the beds are abundant in nutrients and minerals. Eelgrass beds are also an important refuge for juvenile fish.

Many species of fish and shellfish depend on eelgrass beds for spawning, feeding and protection. Chinook and coho salmon spend critical portions of their juvenile lives among the eelgrass. English sole and starry flounder can also be found in this habitat as can dungeness crab, clams, shrimp and a variety of invertebrates. Each February Pacific herring come into the estuary and spawn in eelgrass beds. Many of the waterfowl and numerous gulls can be seen around this time feeding on the herring eggs.

Brants are migratory geese that overwinter in the Yaquina Estuary. The eelgrass beds provide an important food resource, eelgrass comprising nearly 80% of their diet. Other migratory waterfowl will spend part of the year or an entire season in the estuary; many feed in the eelgrass beds looking for crabs and small fish.

**Tideflats:**

Mudflats lay between eelgrass beds and the salt marshes. Mudflats are formed by sediment deposited daily with the flow of fresh and salt water into the estuary.

Twice each lunar day the tide recedes and exposes mudflats to air. The organisms that live in this habitat must be adapted to existing for periods of time without water. Some, such as crabs and fish, avoid this stress by moving out into the eelgrass beds during low tide. Invertebrates such as the ghost shrimp, worms, and clams, deal with low tide exposure by burrowing or digging deep



into the sediments. Some clams retract their necks or siphons and trap water inside their shells. Each of these organisms stays in the mud waiting for the tide to return. The numerous small holes on the surface of the mud indicate the presence of these animals.

The light-brown material seen on the surface of the tideflats is a coating of diatoms. Diatoms are a type of alga that form the basis of estuarine food webs. Zooplankton feed on the diatoms, they in turn are eaten by small invertebrates which are fed upon by larger invertebrates and vertebrates. Thus diatoms are extremely important to organisms in the estuary. Diatoms also produce most of the world's oxygen through the process of photosynthesis.

Many of the animals living in tideflats are filter feeders that strain the water for planktonic or "drifting" food. Most of these invertebrates burrow or dig into the mud. The organisms living within the mud flats are in turn an important food for birds. When the tide is low, the birds take advantage of this resource. Gulls may feed on clams and other bivalves by dropping the shells on hard mud (or a parking lot), and then eating the meat inside. Shorebirds feed on crustaceans and bivalves by poking their narrow, pointed bills into the holes in the mud. When the tide is high, Great Blue Herons and Great Egrets feed in the tideflats by stalking fish on top of the mudflats.

## **Salt Marshes**

Salt marshes are found beyond the upper edge of the mud flats. As deep sediments accumulate over a tideflat, plants begin to colonize the area. The first one to establish is generally pickleweed. Once pickleweed takes hold, it helps to slow down the flow of water. This results in more sediments being deposited and other wetland plants begin to colonize the area. While the lower edge of the saltmarsh may be inundated with every tide, the upper edge is not inundated every day.

Pickleweed, like all salt marsh plants, has special adaptations to survive exposed to saltwater. This plant fills its cells with saltwater. While scientists are not exactly sure how this mechanism works, the end result is an ability to live in a salty environment. Another adaptation to excess salt can be seen in the salt marsh grass which extrudes salt to the outside of its leaves; the salt on the leaf eventually washes off.

The roots of salt marsh plants are usually submerged in water. This creates "anoxic", or low oxygen condition for the roots, which require special adaptations. Some plants have "aerenchyma" or pores within their roots connected to the upper portion of the plant. Through aerenchyma, oxygen can be transported from the surface to the roots.

When salt marsh plants die, bacteria and fungi colonize them and begin to break them down. These "decomposers"

perform an important part of the food cycling in estuaries. The material they break down becomes detritus, or dead organic material. Detritus and plankton, including diatoms, make up the rich "estuarine soup", the abundance of organic material that is so important to the filter feeders living within the estuary.

**Uplands:**

The upland habitats are those regions adjacent to the estuary that are never inundated by salt water. The plants in this habitat do not have their roots submerged in salt water. Upland plants do, however, live in an environment with a high amount of salt in the air. Since salt can be toxic to their cells, they require adaptations to live in this environment such as thick, waxy leaves that help prevent salt from entering their cells.

While some of the upland plants are native to this region, many are not. Scientists consider a plant to be native to an area if it arrived prior to the Europeans. Introduced plants are generally not native to the state, or even to the country, having come originally from Europe. Scotch broom and foxglove are examples of upland plants that originated in Europe. The difficulty they present is that they often outcompete the native plants and may eventually lead to their extinction.

## PLANTS OF THE HMSC ESTUARY TRAIL

### **Achillea millefolium - Yarrow**

A perennial, Yarrow has finely divided leaves and many small white (or rarely pink) flowers. Often larval spittle bugs are found on yarrow. Very common in the state of Oregon, Yarrow is found throughout the U.S. and Eurasia.

Native Americans used the leaves raw to produce sweating during childbirth and to help women recover from childbirth. They also cooked the leaves in a tea to purify the blood or remedy an ailing stomach. Some northwest tribes used the crushed or chewed leaves as a poultice on sores. Yarrow is named after Achilles of Greek mythology who used it for medicinal purposes.

### **Alnus rubra - Red alder**

One of the few types of plants outside of the pea family that can fix nitrogen. Bacteria living in root nodules within the plant take nitrogen from the atmosphere and combine it into a form that plants and other organisms can use. In the aquatic habitat the ability to fix nitrogen provides a competitive advantage.

### **Ammophila arenaria - European beachgrass**

European beach grass has narrow leaves with rolled-under edges, the stems can be 2-6 feet tall. It was introduced from Europe to reduce sand movement along Oregon's beaches. It is an aggressive grass in disturbed sandy sites and works very well in stabilizing sand. Perhaps it works too well as there has been some controversy recently over this plant's presence on Oregon's beaches because it has stopped the natural movement of dunes.

### **Anaphalis margaritacea - Pearly everlasting**

Pearly everlasting has narrow leaves that are green on top and woolly below. The plants have numerous small white flowers with yellow centers that resemble pearls. It is common throughout the Pacific coast from Alaska to California. Also found on the Atlantic coast and in Eurasia.

Some Native Americans used the whole pearly everlasting plant in a steam bath for treatment of rheumatism, others kept their children away from it because it was believed to cause sores.

**Angelica hendersonii - Sea-coast Angelica**

A member of the carrot family, Angelica's stems are stout, 2-6 feet tall, and strong scented. The leaves are divided into threes and fives, green and smooth above and wooly below. Flowers are small, occur in umbels.

Angelica is very common along the seashore especially where beach and bluff meet. It occurs from Southern Washington to California.

Native Americans made baskets out of the umbels by weaving seaweed in between the stems. Not known to be edible.

**Aster chilensis - California aster**

California aster is a purple daisy-like flower with a yellow center. The stems are 1-3 feet tall. California aster occurs from Oregon to California.

**Aster subspicatus - Common wild aster**

Common wild aster is an erect plant that grows up to three feet. The branches end in leafy clusters of violet or purple rayed flower heads. Very common throughout the coast in moist places. Not known to be edible.

**Atriplex patula - Coast saltbrush**

Atriplex grows near the winter high tide line (marked by the presence of driftwood), in the salt marsh habitat. Its adaptation to salinity is to get rid of the salt. Atriplex has a leaf hairs made up of two cells, one on top of the other, the bottom one pumps salt into the upper one (called a vesicle). When the vesicle is full, it bursts, emptying the salt. You can see salt on the bottom of the leaves.

**Baccharis pilularis - Coyote brush, Chaparral broom**

Coyote brush is a shrub that is from 2-5 feet tall. The flowers are small in dense clustered heads. It is found on banks and cliffs from Oregon to California.

**Brassica nigra - Black mustard**

The flowers of mustard are bright yellow and the seed pods are slightly four-angled. Introduced from Europe it is found commonly in fields, roadsides and other disturbed places. The young leaves and flowers have a very definite "mustardy" taste.

Native Americans used the plant as a potherb, they cooked it in several changes of water.

**Carex spp. - Sedge**

The sedge family, Cyperaceae, is important as a source of food and shelter for wildlife. The stems are solid and triangular; "Sedges have edges, rushes are round". Sedges are perennials, found along the coast from British Columbia to California.

**Centaurium umbellatum - Centaury**

An annual, centaury has slender stems and rose-colored flowers clustered in an umbel. Introduced from Europe it is found commonly in disturbed areas.

**Chrysanthemum leucanthemum - Ox-eye daisy**

A white daisy-like flower with a yellow center, Ox-eye daisy blooms in June and early July. It is common in waste areas and deserted fields. Believed to be introduced from Eurasia.

Native Americans dried the stems and flowers of this plant then boiled it and used the wash for chapped hands.

**Cotula coronopifolia - Brass buttons**

A very small yellow aster with only disk flowers, brass buttons is found along beaches and in wet environments from Washington to California.

**Cuscuta salina - Marsh dodder**

Marsh dodder appears as a brownish stringy mass on pickleweed in early July. In late July and August it will have small white flowers that may be mistaken for pickleweed flowers. It is a parasitic plant that twines around the host and cuts a rootlike protuberance into the plant to feed. Dodder will also parasitize other plants, including crop plants like alfalfa.

**Cytisus scoparius - Scotch broom**

A shrub, generally with few small leaves that are usually in leaflets of three. The flowers are in clusters of 2-3 and are a deep yellow.

Introduced from Europe, actually from Scotland, as an ornamental Scotch broom is now widely distributed especially along the coast. Found from Washington to California, the shrubs are used in some areas to stabilize the dunes. Not edible.

**Daucus corota - Queen Anne's lace, Wild carrot**

The stems of wild carrot are stiff and hairy, and branch from a fleshy root with a distinctive carrot odor. The leaves are finely divided. Flowers are small and white with one or more purple petals in the center, borne in umbels.

Introduced from Europe, Queen Anne's lace is very abundant. All varieties of garden carrot are considered derived from this species. The root is edible, although very fibrous.

**Digitalis pupurea - Foxglove**

Foxglove usually has violet flowers, however, approximately 1 in 100 plants will produce white flowers. Stems are up to 9 feet tall. It was introduced from Europe and is very common along the coast. Not edible.

The heart medicine, digitalis, was first extracted from this plant. Its effect on the heart is two-fold. It strengthens the contractions of the heart and also serves to slow it down.

**Dipsacus sylvestris - Common teasel**

A biennial, teasel has stems which have short, stiff, downward-curved prickles. The leaves are large with prickly midribs and veins. The flower heads have stiff, prickly, bracts that are curved upward around the head. The lilac-colored flowers begin at the center in a circle and work their way both upwards and downwards.

Introduced from Europe, the bristly heads are still used in England for raising the nap on some cloth. Common in waste lands.

**Distichlis spicata - Salt grass****Elymus mollis - American beachgrass**

A broader leafed plant than the European bunchgrass, American beachgrass is a perennial that grows 2-6 feet. The leaf blades are blue-green. It grows in moister soil than does the European bunchgrass, establishing itself just above the winter high tide level.

**Escholtzia californica - California poppy**

A common plant in disturbed areas, California poppy has yellow to deep orange petals; it is the California state plant. A common plant in disturbed areas, the poppies on the trail were introduced in 1989.

**Galium aparine - Bedstraw**

Bedstraw is a low, vine-like plant. The stems trail along the ground or climb, and the leaves are whorled on the stem. Flowers sprout from the base of the leaves and are usually small and white. The small hooked projections along the stem, leaf margins and fruit attach to passing animals such as mice or deer. These help to transport the plant to new locations. Common in somewhat shady places.

Related to coffee. Some Native Americans would rub bedstraw on their body after bathing because of its smell. Bedstraw was used as a stuffing material for bedding during the pioneering days. Pioneers and sailors felt that including it in bed ticking would prevent infestations of bed bugs.

**Gaultheria shallon - Salal**

Salal is a spreading evergreen shrub with dark green shiny leaves and white to pink urn-shaped flowers. The berries are dark blue and edible.

Native Americans gathered the fruits to make cakes of the smashed berries. This shrub is often used as an ornamental.

**Grindelia integrifolia - Gumweed**

Gumweed has bright yellow sunflower-like flowers. The entire plant is sticky to the touch. Common in high salt marshes. Not known to be edible.

**Heracleum lanatum - Cow parsnip**

In the umbel family. Ashes from burning have been used as a salt substitute.

**Hypochoeris radicata - False dandelion, (Chinese lettuce, gosmore)**

False dandelion has all basal leaves and yellow flowers which are clustered together in many heads. Common along the coast.

**Jaumea carnosa - Fleshy jaumea**

Found in the salt marsh habitat, (toward the end of the plant growth area), Jaumea produces a yellow dandelion-like bloom in late June to early July. Found from Vancouver Island to California, Jaumea has fleshy succulent leaves; the succulence dilutes the salt content of the tissues.



**Lathyrus japonicus - Beach pea**

A perennial, beach pea has trailing stems from 1-3 feet long. The leaves are bright green with 3-5 pairs of leaflets and the flowers are violet. Found commonly on beaches and coastal environments from Alaska to northern California.

No known native use, however, related species were used for sanitary and medicinal purposes.

**Lonicera involucrata - Honeysuckle or twinberry**

A shrub 2-12 feet tall, Twinberry produces two yellow flowers at each flowering point. The berries, also in pairs, are black when mature and very sour.

**Lotus micranthus - Birdsfoot trefoil, lotus**

A fairly common plant, lotus leaflets are often in threes and rounded. The flowers are yellow and the seed pods are slender. Fairly common.

No known native use for the plant, assumed to be non-edible.

**Lupinus arboreus - Yellow tree lupine**

Tree lupine is a native of the northern California coast and was introduced to the Oregon and Washington coasts. It is very common and not edible.

Lupine is a member of a family of plants, the legumes or pea family, which has the capability of "fixing" nitrogen. Nodules in the roots house bacteria that take nitrogen from the atmosphere and fix it into a form the plant can use. It releases any excess fixed nitrogen into the soil. When the plant root decays, the nitrogen that it contains is also released for use by other organisms. The dredge spoil that is along the trail is bad soil for most plants to grow in, principally because it is low in nutrients, particularly nitrogen. Lupine is a good competitor in this area.

**Myrica californica - Oregon Wax Myrtle**

A member of the sweet gale family, Myrtle is a shrub or small tree that grows up to 30 feet in height. The leaves are evergreen and leathery, the fruit is reddish-brown, waxy, and nut-like. Common along the coast, Myrtle is found from Washington to northern California. In some places is planted for its ornamental beauty.

**Orthocarpus castillejoides - Salt marsh owl clover**

Found from British Columbia to California.

**Parentucellia viscosa - Eye bright**

An annual herb with bright yellow flowers that occur in spikes. The plant is hairy and sticky to the touch. Common in disturbed areas, it was introduced from Europe.

Native Americans made tea out of the leaves; it was believed to enhance vision.

**Picea sitchensis - Sitka spruce**

An evergreen tree that grows up to 180 feet tall, Sitka spruce needles are squarish in shape, (cross-wise), very sharp, and are borne individually along the stem, rather than in bunches or fascicles. Found from Alaska to California, this is the only species of the pine family which can survive in water-saturated soils. In this area it occurs in a very narrow strip along the coast.

The wood of Sitka spruce is strong yet lightweight, it was used in the wings of WWI biplanes. A mill was built in Toledo to produce wing-spars. However, harvesting of sitka spruce stopped just as the mill was being completed when the war ended.

**Plantago hirtella - Mexican plantain**

A perennial, plantain is brownish and woolly, flowers are in dense spikes. Commonly found along wet coastal ground. No known use by natives and not known whether it is edible.

**Plantago lanceolata - English or black plantian**

Similar to Mexican plantain but with hairy leaves and shorter spikes. Introduced from Europe and now quite common in yards and disturbed areas in the Pacific states. The pollen is believed to be troublesome as a hayfever plant. Not believed to be edible.

**Polystichum munitum - Sword fern**

Sword fern has a little projection, a "thumb", at the base of the leaves. Though more common inland, they are found along the coast.

Native Americans used sword fern as a lining for their cooking pits, and their drying racks because few things would stick to the leaves. Medicinally, the young shoots were eaten in belief that it cured tonsillitis.

**Rhamnus purshiana - Cascara, Chittum**

A shrub or small tree, cascara can reach 7m in height. The leaves are deciduous and have parallel lateral veins. The fruit is black with a sickly sweetish taste. Common in Oregon.

Native Americans ate the berries when they were fresh and bioled the bark to make a green dye. The bark was universally used as a laxative and is still sought after for its medicinal value. Berries have a laxative effect.

**Rubus discolor - Himalayan blackberry**

The stems are thick and long with flat, curved prickles. Generally 5 leaflets on the mature bushes and 3 on the immature. Leaves are green above and white beneath.

Introduced from Europe and now well established in Western Oregon. A very aggressive plant that has displaced many of the native varieties of blackberries. Edible berries.

**Rubus urcinus - Wild or trailing blackberry**

The native variety, wild blackberry is a trailing vine-like plant with slender leaves. Leaflets are generally in three's. Edible berries.

**Rubus laciniatus - Evergreen blackberry**

Has dissected leaves. Edible berries.

**Rumex acetosella - Red sorrel, Sour dock**

Red sorrel has thin somewhat arrow-shaped lower leaves, while the upper ones are smaller and narrower. The flowers are tiny and red-yellow. Very common in disturbed areas where there is acidic soil. The leaves are very acidic, like rhubarb, which is in the same family.

**Rumex crispus - Curly dock**

The stems of curly dock are stout with long, narrow bluish green leaves that have curly margins. Flowers are tiny and red, found in dense clusters. The tiny seeds are heart-shaped.

Introduced from Europe it is quite common in waste areas and abundant around deserted buildings. Not edible.

**Salicornia virginica - Pickleweed**

Found in the salt marsh habitat, (near the end of the plant growth area), pickleweed blooms late June to early July, but it has inconspicuous flowers. Pickleweed has a fleshy succulent stem; the succulence acts to dilute the salt content of the tissues. Edible.

**Salix hookeriana - Willow**

A member of the Salicaceae family, willows have unisexual flowers in catkins. A large shrub or small tree, willows range from 6-27 feet. The leaves are dark above and light below. Flowers appear before the leaves. Common along the coastal fog belt from Canada to California. Native.

Native Americans made rope out of the bark and made tea from the leaves to cure aches and pains. Some species contain salicylic acid, the principal ingredient in aspirin.

**Scirpus americanus - American bulrush**

The plant looks fleshy or succulent, like pickleweed, but its fleshiness is due to specialized tissues called aerenchyma, which transport oxygen to the roots. This is an adaptation to life far out in the tidal zone where they are partly submerged much of the time. To deal with excess salt, some researchers believe that American bulrush holds the salt in a site within the cell, an inner sack.

**Senecio jacobaea - Tansy ragwort**

A perennial, tansy ragwort has yellow ray-flowers and brownish-yellow disk flowers. Introduced from Europe, is common in pastures and disturbed. Very toxic to some livestock (cows and horses), causing severe liver damage.

**Trifolium pratense - Red clover**

With more or less hairy stems and veined often dark leaves, the flowers of red clover are deep magenta red or purple. The pod is two seeded. Common.

No known use by the natives though it is believed that they might have eaten the leaves and flowers.

**Triglochin maritimum - Arrowgrass**

Arrowgrass grows in a few isolated clumps among the fleshy jaumea and pickleweed in the salt marsh habitat. It is taller than the jaumea by a foot or so. Notice how similar the plant looks to small green onions. It contains hydrogen cyanide and so is inedible.

**Vaccinium ovatum - Huckleberry**

Huckleberry is a member of the heath family. Young leaves and berries are red. Edible.

**Vicia gigantea - Giant vetch**

The flowers of vetch are red to deep purple, though they can be a pale yellow. Generally there are 6-10 pairs of leaflets and the stems are usually smooth although they can be somewhat hairy. Common along the coast throughout the Pacific states. Believed to be introduced from Europe.

Native Americans used the vetch to cover sprouts when steaming them. The women also used the water from the soaked root to wash their hair. Women whose husbands had left would rub their body with the roots and put them under their pillow in hopes of bringing their husbands back.

**Plants Along the HMSC Estuary Trail: Common and Latin Names**

American beachgrass - Elymus mollis

American bulrush - Scirpus americanus

Arrowgrass - Trioglochin maritima

Beach pea - Lathyrus japonicus

Bedstraw - Galium aparine

Black mustard - Brassica nigra

Brass buttons - Cotula coronopifolia

California aster - Aster chilensis

California poppy - Escholtzia californica

Cascara - Rhamnus purchiana

Centaury - Centaureum umbellatum

Coast saltbrush - Atriplex patula

Chapparal broom (Coyote brush) - Baccharis pilularis

Common teasel - Dipsacus sylvestris

Common wild aster - Aster subspicatus

Cow parsnip - Heracleum lanatum

Curly dock - Rumex crispus

English (black) plantain - Plantago lanceolata

European beach grass - Ammophila arenaria

Evergreen blackberry - Rubus laciniatus  
Eye bright - Parentucellia viscosa  
False dandelion (Chinese lettuce) - Hypochoeris radicata  
Fleshy jaumea - Jaumea carnosa  
Foxglove - Digitalis purpurea  
Giant vetch - Vicia gigantea  
Gumweed - Grindelia integrifolia  
Himalayan blackberry - Rubus discolor  
Honeysuckle (twinberry) - Lonicera involucrata  
Huckleberry - Vaccinium uliginosum  
Lotus (birdsfoot trefoil) - Lotus micranthus  
Marsh dodder - Cuscuta salina  
Mexican plantain - Plantago hirtella  
Oregon wax myrtle - Myrica californica  
Ox-eye daisy - Chrysanthemum leucanthemum  
Pearly everlasting - Anaphalis margaritacea  
Pickleweed - Salicornia virginica  
Red alder - Alnus rubra  
Red clover - Trifolium pratense  
Red sorrel (sour dock) - Rumex acetosella  
Salal - Gaultheria shallon  
Salt grass - Distichlis spicata  
Salt marsh owl clover - Orthocarpus castillejoides  
Scotch broom - Cytisus scoparius  
Sea coast Angelica - Angelica hendersonii  
Sedge - Carex spp  
Sitka spruce - Picea sitchensis  
Sword fern - Polystichum munitum  
Tansy ragwort - Senecio jacobaea  
Wild blackberry - Rubus urcinus  
Wild carrot - Daucus corota  
Willow (coast) - Salix hookeriana  
Yarrow - Achillea millefolium  
Yellow tree lupine - Lupinus arboreus

## AQUATIC BIRDS OF THE HMSC ESTUARY TRAIL

**Black Brant** - Some are present throughout the year, most are common from October through May. Brants have a long term pair bond. They breed in low arctic tundra and river deltas showing strong nest site tenacity, the tendency to return each year to the same nest site or colony. Winter to southern Baja. Their most important food is eelgrass.

**Bufflehead** - Winter resident, common October through mid-May.

Nest in mixed conifer-deciduous woodland near lake. Buffleheads have long term pair bonds and strong fidelity to breeding and wintering areas. When feeding in small groups, one sentry usually stays on the surface while others dive.

**Canvasback** - Winter resident, common from early October through mid-May

**Coot, American** - Winter resident, common from mid-August through May

**Cormorant:**

Cormorants have the ability to dive down to approximately 180 feet below the surface of the water in order to catch fish. To do this they are built somewhat differently than most aquatic birds. The gland at the base of the tail which secretes oil for aquatic birds to spread on their feathers to keep them dry is present in the Cormorants, but it secretes very little oil. Consequently, Cormorants can often be seen perched on a rock or a piling with their wings spread to dry.

**Brandt's** - Present throughout the year.

**Double crested** - Some are present throughout the year, most common from August through May.

**Pelagic** - Present throughout the year.

**Dowitcher:**

**Long-billed** - Winter resident, some may remain throughout the year, most common from mid-March through mid-May.

**Short-billed** - Migrant, common in April and May.

**Ducks:**

In ducks, the males and the females often look different. However, after the breeding season the males molt, and for a period they resemble the females. This is termed "Eclipse plumage". The advantage appears to be that because the males are so colorful during breeding season that they are more susceptible to predation. By molting after breeding season they are better camouflaged from predators.

Ducks are most numerous in Yaquina Bay in fall and winter. There are two types of ducks: diving and surface feeders. Surface-feeding ducks such as Mallards and Northern Pintails simply feed on vegetation that they can reach while walking or swimming. Diving ducks such as scoters, scaups, and Canvasbacks dive underwater to find food on the bottom or in the water column.

**Harlequin** - Some are present throughout the year, most are common from mid-August through May.

**Ring-necked** - Winter resident, present from September through mid-May.

**Ruddy** - Winter resident, common from the end of September through mid-May.

**Dunlin** - Winter resident, common from mid-July through May.

**Great Egret** - Winter resident, common from the end of July through mid-April.

**Gadwall** - Winter resident, common from August through mid-April.

**Godwit, Marbled** - Some may be present throughout the year, most are common in April and May.

**Goldeneye, Common** - Winter resident, common from the end of October through mid-April.

#### **Grebes:**

Grebes are able to dive up to 40 feet below the surface of the water. When diving they can squeeze much of the air out of their feathers, and partially deflate their air sacs, "trimming" themselves to float at any level or to submerge.

**Horned** - Winter resident, common from August through early June.

**Pied-billed** - Winter resident, common from early August through May

**Western** - Most present mid-September through May, (some throughout the year).

**Guillemot, pigeon** - Summer resident, common from February through October.

#### **Gulls:**

**Bonaparte's** - Summer resident, common from April through December. Attain their adult plumage at two years. In breeding plumage Bonaparte's have a black head, non-breeding have a white head with a black spot behind the eye. As the water recedes following a high tide, they feed by standing on tiny puddles on the mudflat and walking in place as though they were trampling grapes for wine. This motion stirs up invertebrates in the puddles which they eat.



**California** - Some persistent throughout the year, most present from June through mid-April

**Glaucous -winged** - Present throughout the year. Hybridizes with Western gulls in this region.

**Heerman's** - Migrant, common in June and November

**Ring-billed** - Persistent throughout the year

**Mew** - Closely resemble the ring-billed but they have a finer, unmarked bill.

**Western** - Present throughout the year. A few nest on pilings, breakwaters, navigation markers, and on the Yaquina Bay Bridge in Yaquina Estuary. Most nest in large colonies along the coast on islands such as at Yaquina Head. Western gulls can be seen flying low over the parking lot adjacent to the Center dropping cockles, a clam-like animal onto the pavement to crack open the shells.

**Heron, Great Blue** - Common throughout the year, they build large nests high up in trees.

**Killdeer** - Common throughout the year

**Kingfisher, Belted** - Common throughout the year.

#### **Loons:**

**Common** - Some present throughout the year, most common from early October through May.

**Pacific** - Some present throughout the year, most common from early November through May.

**Mallard** - Present throughout the year, nest in marshes along some of the sloughs of Yaquina Estuary.

#### **Mergansers:**

**Common** - Present throughout the year, nest in the upper estuary of Yaquina Bay. They breed in lakes and rivers in forested areas.

**Hooded** - Some present throughout the year, most common from the end of October through May.

**Red-breasted** - Winter resident, common from mid-October through early June.

**Murre, Common** - Present throughout the year.

**Pelican, Brown** - Migrant, common in the late summer, June - December, migration.

#### **Phalaropes:**

**Red** - Migrant, common in May and from September through December.

**Red-necked** - Migrant, common April and May, and August through December.

**Pintail, northern** - Winter resident, common August through May.

**Plovers:**

**Black-bellied** - Some present throughout the year, most present from late July through May.

**Semipalmated** - Migrant, common April and May, and July through October.

**Sanderling** - Winter resident, common from early August through May. They breed far north in dry sedge and on the barren tundra. Unpaired males will advertise and defend a territory with flight and ground displays. Males and females occasionally incubate separate clutches and care separately for young.

**Sandpipers:**

**Least** - Winter resident, common from early July through May.

**Western** - Some present throughout the year, most common late June through May.

**Scaups , Greater** - Breed in ponds in forests or tundra. May lay eggs in nest of other Greater Scaups. Male deserts when incubation begins. Females often combine broods and cooperatively tend and defend. Can dive to 20 feet and stay underwater for one minute.

**Scoters:**

**Surf** - Some present throughout the year, most common from mid-August through mid-May. Surf scoters breed in bogs or ponds. When they're swimming and diving scoters keep their wings partially open and use them for paddling and steering.

**White-winged** - Some present throughout the year, most common from mid-August through mid-May. White-winged scoters breed in open tundra, taiga, or prairie ponds. They begin nesting later than all other ducks. Females occasionally lay eggs in nests of other white-winged females and other duck species, a habit referred to as brood parasitism. They can dive to 40 feet and are strong swimmers. Like other divers, they have high wing-loading, or small wings to body size, so they must run across surface to take off.

**Snipe, common** - Some present throughout the year, most common from mid-September through mid-May

**Surfbird** - Winter resident, common from early July through mid-May

**Teal, green-winged** - Winter resident, common mid-August through early May

**Terns:**

**Arctic** - Migrant, common in May, and from September through mid-October. As their name implies, they breed high in the arctic and winter near the southern tip of South America and as far south as Antarctica.

**Caspian** - Summer resident, common from early April through mid-October

**Common** - Migrant, common in May, and from August through early October

**Turnstone, Black** - Winter resident, common from July through early May

**Whimbrel** - They are most numerous in May, but some nonbreeders commonly oversummer and a few overwinter. Thus, they can be found here throughout the year. Near dusk, they fly in noisy flocks from the Yaquina Estuary towards the ocean to spend the night. They catch invertebrates such as mud shrimp with their long bills.

**Wigeon, American** - Winter resident, common from August through May. If the young are disturbed the female feigns injury, the young scatter and when they are hidden she flies away.

## **NATIVE AMERICANS OF YAQUINA BAY**

### **Pre-historic Movements**

The Coastal Salish, the first known people of the Pacific coast, are believed to be from a population of wanderers who came from east of the Rockies in south Alberta. Originally hunters, these bands began to take salmon from the Columbia river sometime before 9000 years ago, and adapted to a new life as fishermen.

The most southerly of the Salish speakers, the Tillamook, and their relatives the Yaconas, who were to eventually become the people of Yaquina Bay, lived on the northern and central Oregon coast during historic periods. These tribes had close language ties with the Twana of the Hood Canal bands and the interior Columbian Salish. The early Tillamook, Yaconas, and Twana probably initially moved from east of the Cascades into southern Puget Sound where they remained for some time. Later, the Tillamook and the Yaconas came southward to the lower Columbia, and from there on down the coast. Later, Penutian speaking people migrated down the Columbia to its mouth, separating the Tillamook and Yaconas from the Salish of the Washington side.

### **Oregon Coast Settlements**

While it is known that the Tillamook and the Yaconas have lived on the Oregon coast since 1400, evidence suggests they may have been there even earlier. An analysis of the contents of the midden site at Yaquina Head suggests that

pre-Yacona bands inhabited the region as far back as 5000 years ago, when the sea level was more than 30 feet lower than it is today. Three thousand years ago the ocean was 12 feet below present level. Those prehistoric beaches, now covered by the sea, were the sites of the first coastal Indians. The site at Yaquina Head was deserted about 2000 years ago because of wave erosion and rising seas.

The Yaconas seasonally traveled from place to place in search of food. Midden sites contain remains from their summer camps, where they fished, gathered molluscs, and hunted sea lions and seals. (The word "midden" means trash heap or garbage pile and is the common term used by anthropologists to refer to a Native American site). Evidence suggests that the pre-historic Yaconas visited coastal areas, but did not have permanent villages there.

Mussels were the most common mollusc they collected, along with clams and piddocks. Nearly 1/4th of their diet consisted of fish, 9% birds, (scaups, scoters, mergansers and cormorants), and 3% marine and forest mammals, (deer, elk, sea lions, northern fur seals, whales, and sea otters.) They also ate grains and collected berries and potherbs.

There's a large midden site at Seal Rock. While much of it has been destroyed by erosion, construction, (contents were used to pave roads during the early 30's), and the mining of sea lion teeth by early white settlers, anthropologists have learned much about the local Native

Americans from that site. Materials at the Seal Rock site date occupation there to 3000 years ago. Along with collecting shellfish , Stellar Sea Lions were hunted using barbed composite harpoons. Another midden at Whale Cove actually dates to over 3000 years ago. This site contains the remains of wolf. Indians from this period hunted harbor seals, California Sea lions, northern fur seals, and sea otters, along with elk, deer, rabbit and bear. The harbor seal was probably the most common food.

Although their ancient ancestors had been hunters, the Yaconas were primarily fishermen, and salmon was their primary food. While Chinook salmon was taken in midsummer, Coho and Chum were caught during the early autumn runs. The last two species were caught with both traps and harpoons. Flounder, next in importance to salmon, was speared with a sharp stick. The fishermen waded on the mudflats at low tide and located the flounder by stepping on them. A spear was used to disable the fish in much the same way that a club of vine maple was used to kill a salmon. Steelhead trout were taken in late fall and winter, and herring, sturgeon, perch, and smelt all added to the diet of these Native Americans.

Spears and clubs were also used to capture beavers after they were dug from their dens. At times sea lions and seals were hunted; a two pronged harpoon was used for spearing these larger animals. Whales were too large to

hunt, but if a dead one beached itself many parts of it were used. The Yaconas also collected and ate the roots of the camas and other plants such as skunk cabbage.

It was a native custom to burn off coastal growths of giant bracken ferns and other underbrush to enhance the hunting of deer and elk. The practice of annual burns provided new growth, which was necessary as food for the next year's game crop and to supply raw materials from which baskets were woven. The women made baskets while the men made fish and bird traps.

To make arrows that were straight and true, the Yaconas took slender shafts of wood and heated and steamed them over a fire. As the wood became soft the men twirled it back and forth in a grooved stone. This worked out the kinks and made the shaft smooth. They finished the shaft by rubbing it with scouring rush.

Women made needles from the wing bone of Great blue herons. They would sew through cattails to make water proof mats. The mats were used for ground cover, sleeping , and rain capes. They were also used to line lodges and make summer shelters.

The Yacona winter dwelling, a plank house, was built over a pit that was about five feet deep. To make house boards they would take several elk horn or bone wedges and drive them along the edge of a log, either cedar or driftwood. Gradually a crack was made in the wood and

larger wedges of yewwood were worked into the spaces. Eventually the soft cedar would split and a long plank would pop free from the log. The Yaconas would then use a stone tipped hand adze to thin and smooth the planks into boards to make the plank homes. Fishing camp houses were less substantial structures, durable for one or two seasons.

Women and men wore dentalia shells and bone pendants as necklaces and nose and ear fixtures. The tusk-like dentalia was highly prized, the length of the shell graded its quality and worth. The longest and most valuable, up to three inches, came from the waters off of Vancouver Island and were used as money.

The Yaconas were constantly at war with other tribes including the neighboring Kalapuya tribe to the east. While attacks on other Indians for slaves were one of the primary reasons for warfare, "flatheads" never enslaved other flatheads, (the Yaconas were flatheads) To assure that their children would not be placed into slavery, they placed pressers, (a leather-bound vise-like flattening frame), on the heads of the baby shortly after birth, deforming the facial contour of the child. Many of the coastal peoples used head-pressers to bring about the flathead condition which lasted into adulthood.

Shamans, who were equivalents to priest doctors, formed the basis for much of the Yacona religion. The sun, moon, stars, thunder, many animals, and the west wind were thought



to possess guardian spirits. Power was derived from the attainment of these spirits and the shaman possessed many strong spirits to help him. The shaman, often the wealthiest member of the tribe, was paid to heal tribal members. Birds, primarily the raven, depicted the spirit cosmos for the people. Feathers of the pileated woodpecker and Stellers jay were the most prized. The people buried their dead in canoes and they believed in an afterlife.

The Yacona territory included the Yaquina river and bay and its adjacent lands. At the end of the 18th century their domain stretched down the coast to Beaver Creek and north up to Otter Rock and Cape Foulweather.

The first Euroamerican to come to the land of the Yaconas may have been a trapper named Bill Cannon in 1811. Lt. Talbot was the first to mention the Yacona Indians; describing them as subsisting on fish, clams, crabs, and roots. Presumably, there were 56 villages situated throughout the Yaquina River system. Probably many villages places were temporary fishing spots, occupied only occasionally during salmon runs.

Due to contact with Euroamericans, many tribal members died from tuberculosis and other diseases. The "Coastal Reservation" which included Yaquina Bay, was established in the mid-1880's. Many Yaconas were sent there. Today there is a confederated Siletz tribal group that is maintaining and enhancing its cultural history.

### YAQUINA BAY HISTORY

The first known European in this area was Captain Cook who came through in 1778. Cook named Cape Perpetua, to the south of Newport, yet apparently missed Yaquina Bay. He spent months just off of Cape Foulweather, never making it to land. The name Cape Foulweather comes from his voyage.

The first written mention of this area by Europeans was in 1826 by a trapper from Hudson Bay who came with five whites, three Iroquois and some Hawaiian Islanders. A journalist accompanied the trip who recorded the trapping of 60 beavers and river otters. There was no mention of sea otters in the log.

Until the discovery of oysters in the estuaries of the Central Oregon coast, there is little other record of Euroamericans in this area. In the summer of 1849, a Lt. Talbot who was visiting from Ft. Vancouver found oysters in Yaquina Bay. His discovery marked the beginning of Euroamericans interest here.

*Ostrea lurida* is the oyster native to Yaquina Bay. It spawns first as a male, then as a female, then as a male, and so on. The Japanese oyster, *Crassostrea gigas*, which has been introduced in the bay, spawns as a male for a couple of years and then as a female. In Oregon, Oysters are technically classified as farm animals.

In 1856, the first known vessel entered Yaquina Bay. The passengers included businessmen from California who

learned about the abundance of oysters. Upon their return to San Francisco generated interest in this area and stimulated a race by a few companies to gain control of the oyster harvest. In 1861 the first San Francisco firm started commercially harvesting Yaquina oysters.

The oysters from Yaquina Bay were shipped to San Francisco which created even more interest in the central Oregon coast and in Newport. More companies moved in to harvest this valuable resource. The Euroamericans hired local Native Americans to harvest the oysters. (It was actually the Indian women who did the harvesting.)

In the 1850's there were a series of bad fires along the central Oregon coast. Subsequent landslides increased the turbidity of the rivers and estuaries. The oyster beds in many areas became silted out and the oysters suffocated. However, they did survive here in Yaquina Bay and the industry flourished. Many canneries were eventually built along the Bay.

Other natural resources that attracted people to the Yaquina Bay area included timber, fishing, particularly for salmon, and to a lesser extent, coal mining. Low quality coal was produced in coal mines up the road between Newport and Toledo. The coal was mined for personal, not commercial use.

The Yaquina Bay lighthouse was built at the entrance to the Bay in 1871. It functioned for only a couple of years

because it was discovered that Yaquina Head blocked the light from the north. Once the lighthouse at Yaquina Head was built, the one at the bay was turned off.

The jetties at the harbor entrance were built in the late 1880's. Before they were built the shoreline was at the base of the cliff, all of the sand on the beach in front of the cliff has accreted due to the jetties.

During the time of prohibition tourists from the Willamette Valley would take the train to what is now Sawyers landing where they would board a barge for a trip down the bay to Newport. Here they would vacation and enjoy spirits that were not available in the valley.

The Newport Bay bridge, completed in 1936, was last link of the bridges along the Oregon coast. Prior to building the bridge, a ferry would transport people and goods across the bay. The ferry terminal was adjacent to the land the Marine Science Center sits on.

#### **The Marine Science Center: 1965**

According to charts in the Marine Science Center's archives dating back to 1860, the land the Center is standing on had actually been an island. The main channel of Yaquina Bay has been dredged many times to allow deep draft vessels to enter the harbor. In the past, dredge spoil was dumped in the region of the original island, eventually creating the peninsula that the Center sits on.

The area where where South Beach Marina and parts of the South Beach community currently sit are all part of the dredging operation. Broken bits and pieces of shells that can be seen along the estuary trail are from the dredging operations and are termed "dredge spoil".

In the 1960's, Wayne Bert who was the head of the Oceanography department at Oregon State University, was interested in establishing a permanent dock and support facility for the University's research vessel. He applied for, and received, a federal grant to fund the project. The grant funded the buildings at the Center that were constructed in 1965. The granting agency had a stipulation that there would have to be a public education wing as part of the Center. The existing aquarium was built for that purpose.

### RECOMMENDED READING

Birds of North America, a field guide. 1987. National Geographic Society. 464 pp.

The Birder's Handbook: A field guide to the natural history of North American birds. By P. R. Ehrlich, D. S. Dobkin, and D. Wheye. 784 pp.

The Ecology of Estuarine Channels of the Pacific Northwest coast: A community profile. By C. A. Simenstad. 1983. U. S. Fish and Wildlife Service. FWS/OBS-83/05. 181 pp.

The Estuary Book. By M. Byrne. 1981. Ministry of the Environment, Province of British Columbia. 39 pp.

Familiar Birds of Northwest Shores and Waters. By H. B. Nehls, Portland Audubon Society. 1975 Durham and Downey, Inc. Portland, OR.

The Good Guide: A sourcebook for interpreters, docents and tourguides. By A. L. Grinder and E. S. McCoy. 1985. Ironwood Publ., Scottsdale AZ. 147 pp.

The Indians of Yaquina Bay. By E. Wayne Courtney. 1989. Sanderling Press. Corvallis, OR. 44 pp.

Native Americans of the Pacific Coast: Peoples of the Sea Wind. By Vinson Brown. 1985. Naturegraph Publishers, Inc. Happy Camp, CA. 272 pp.

On Interpretation: Sociology for Interpreters of Natural and Cultural History. G. E. Machlis and D. R. Field, eds. 1984. Oregon State Univ. Press, Corvallis OR.

Plants of the Oregon Coastal Dunes. By A. M. Wiedemann, L. J. Dennis, and F. H. Smith, Dept of Botany, Oregon State University. 1974. O.S.U. Book Stores, Inc. Corvallis, OR. 117 pp.

Wetland Plants of the Pacific Northwest. U.S. Army Corps of Engineers. Seattle, WA. 85 pp.

Wetlands. 1986. By W. J. Mitsch and J. G. Gosselink. Van Nostrand Reinhold, New York, N.Y. 539 pp.

Yaquina Bay 1778-1978. By D. Castle, B. Eddleman, M. Hughes, R. Hughes, P. Thompson. 1979. Lincoln County Historical Society, Newport Oregon.

## Appendix IV

Degree Categories of College Graduate Majors  
and Post Graduate Areas of Study,  
of Participants in the Estuary Trail  
Education Study

| Table IV.1 - Majors and Areas of Study in the Degree Category Natural Science |                       |
|---|-----------------------|
| Major/Area of Study   | Number of Respondents |
| Aquatic Ecology   | 1                     |
| Biology   | 22                    |
| Botany  | 4                     |
| Ecology   | 2                     |
| Entomology  | 1                     |
| Environmental Science   | 1                     |
| Fish/Wildlife   | 1                     |
| Forest/Range Management   | 1                     |
| Forestry  | 7                     |
| General Science   | 3                     |
| Geography   | 8                     |
| Geology   | 2                     |
| Marine Biology  | 2                     |
| Oceanography  | 1                     |
| Plant Science   | 1                     |
| Science   | 1                     |
| Soil Science  | 1                     |
| Wildlife Biology  | 1                     |
| Wildlife Management   | 1                     |
| Zoology   | 8                     |

| Table IV.2 - Majors and Areas of Study in the Degree Category Other Science |                       |
|---|-----------------------|
| Major/Area of Study   | Number of Respondents |
| Agriculture   | 3                     |
| Agronomy  | 2                     |
| Anesthesiology  | 1                     |
| Biochemistry  | 7                     |
| Chemistry   | 10                    |
| Dental  | 1                     |
| Emergency Medical   | 1                     |
| Energy/Conserv/Management   | 1                     |
| Environmental Health  | 2                     |
| Health  | 2                     |
| Health Administration   | 1                     |
| Horticulture  | 2                     |
| Landscape Design  | 1                     |
| Math  | 5                     |
| Medicine  | 9                     |
| Microbiology  | 3                     |
| Neuroscience  | 1                     |
| Nursing   | 17                    |
| Nutrition   | 2                     |
| Optometry   | 2                     |
| Pharmacy  | 3                     |
| Physical Therapy  | 2                     |
| Physics   | 4                     |
| Public Health   | 2                     |
| Radiology   | 1                     |
| Speech Pathology  | 1                     |
| Veterinary Medicine   | 3                     |



| Table IV.3 - Majors and Areas of Study in the Degree Category Engineering |                       |
|---|-----------------------|
| Major/Area of Study   | Number of Respondents |
| Agricultural Engineering  | 1                     |
| Chemical Engineering  | 1                     |
| Civil Engineering   | 3                     |
| Computer Engineering  | 1                     |
| Electrical Engineering  | 6                     |
| Engineering   | 22                    |
| Mechanical Engineering  | 2                     |

| Table IV.4 - Majors and Areas of Study in the Degree Category Education |                       |
|---|-----------------------|
| Major/Area of Study   | Number of Respondents |
| Agricultural Education  | 2                     |
| Art Education   | 1                     |
| Early Childhood Education   | 2                     |
| Education   | 31                    |
| Education Administration  | 1                     |
| Elementary Education  | 16                    |
| English Education   | 1                     |
| Environmental Education   | 2                     |
| Health Education  | 2                     |
| Music Education   | 4                     |
| Nursing Education   | 1                     |
| Science Education   | 3                     |

| Table IV.5 - Majors and Areas of Study in the Degree Category Liberal Arts |                       |
|--|-----------------------|
| Major/Area of Study  | Number of Respondents |
| Anthropology   | 5                     |
| Archaeology  | 1                     |
| Architecture   | 3                     |
| Art  | 10                    |
| Administration Justice   | 1                     |
| Classics   | 1                     |
| Communication  | 7                     |
| Counseling   | 2                     |
| Creative Writing   | 1                     |
| Drafting   | 1                     |
| Dramatic Art   | 1                     |
| Energy Policy  | 1                     |
| English  | 18                    |
| Government   | 1                     |
| Graphics   | 1                     |
| History  | 12                    |
| Home Economics   | 4                     |
| Interdisciplinary Studies  | 1                     |
| International  | 2                     |
| Journalism   | 6                     |
| Languages  | 7                     |
| Law  | 7                     |
| Liberal Studies  | 3                     |
| Library Science  | 2                     |
| Literature   | 1                     |
| Music  | 2                     |
| Political Science  | 6                     |
| Psychology   | 12                    |

|                |   |
|----------------|---|
| Recreation     | 2 |
| Social Science | 6 |
| Social Studies | 2 |
| Sociology      | 4 |
| Speech         | 2 |
| Theater        | 1 |
| Theology       | 3 |

| Table IV.6 - Majors and Areas of Study in the Degree Category Business |                       |
|--|-----------------------|
| Major/Area of Study  | Number of Respondents |
| Accounting   | 10                    |
| Agricultural Economics   | 2                     |
| Business   | 27                    |
| Business Administration  | 13                    |
| Business Management  | 4                     |
| Commerce   | 1                     |
| Computer Science   | 7                     |
| Economics  | 12                    |
| Finance  | 6                     |
| Forest Products  | 1                     |
| Industrial Relations   | 1                     |
| Management   | 2                     |
| Marketing  | 1                     |
| Public Administration  | 1                     |

| Table IV.7 - Majors and Areas of Study in the Degree Category Technical/Other |                       |
|---|-----------------------|
| Major/Area of Study   | Number of Respondents |
| Deaf Interpreter  | 1                     |
| Diesel OT   | 1                     |
| Electronics   | 2                     |
| Hair Design   | 1                     |
| Handicapped   | 1                     |
| Landscape Contractor  | 1                     |
| Landscape Contractor  | 1                     |
| Machinist   | 1                     |
| Merchant Marine   | 1                     |
| Secretarial Science   | 1                     |
| CIS   | 1                     |
| Community Service   | 1                     |
| Correction  | 1                     |
| I ed  | 1                     |
| MSW   | 1                     |
| NSG   | 1                     |
| Social Work   | 4                     |
| Techniology   | 1                     |

## Appendix V

Visitor Demographics and Characteristics:  
Percent Participation by Study Group.

| Table V.1 - Percent of Males and Females in Study Groups. |                    |                 |                     |                       |                  |
|---|--------------------|-----------------|---------------------|-----------------------|------------------|
| Sex   | Control<br>(n=264) | Sign<br>(n=328) | Brochure<br>(n=181) | Naturalist<br>(n=124) | Study<br>Average |
| Females   | 51                 | 54              | 50                  | 56                    | 52               |
| Males   | 47                 | 41              | 48                  | 40                    | 44               |

Percentages do not add to 100 because 4% of the participants circled both male and female.

| Table V.2 - Percent of Study Group Participants in Age Categories. |                    |                 |                     |                       |                  |
|--|--------------------|-----------------|---------------------|-----------------------|------------------|
| Age  | Control<br>(n=264) | Sign<br>(n=327) | Brochure<br>(n=181) | Naturalist<br>(n=124) | Study<br>Average |
| 18-27  | 13                 | 12              | 11                  | 10                    | 12               |
| 28-37  | 23                 | 23              | 25                  | 16                    | 22               |
| 38-47  | 30                 | 31              | 31                  | 37                    | 31               |
| 48-57  | 15                 | 15              | 17                  | 17                    | 16               |
| 58-67  | 15                 | 12              | 10                  | 14                    | 13               |
| 68 +   | 4                  | 7               | 7                   | 6                     | 6                |

| Table V.3 - Percent of Study Group Participants<br>in Education Levels. |                    |                 |                     |                       |                  |
|---|--------------------|-----------------|---------------------|-----------------------|------------------|
| Education   | Control<br>(n=263) | Sign<br>(n=328) | Brochure<br>(n=181) | Naturalist<br>(n=124) | Study<br>Average |
| Elementary/<br>Some High<br>School                                      | 2                  | 3               | 2                   | 1                     | 2                |
| High School<br>Graduate   | 14                 | 15              | 11                  | 10                    | 13               |
| Some<br>College   | 31                 | 31              | 29                  | 31                    | 31               |
| College<br>Graduate   | 30                 | 27              | 29                  | 33                    | 29               |
| Post-<br>graduate<br>Education  | 23                 | 24              | 29                  | 25                    | 25               |

| Table V.4 - Percent of Study Group Participants<br>in College Degree Categories. |                    |                 |                    |                      |                  |
|--|--------------------|-----------------|--------------------|----------------------|------------------|
| Degree   | Control<br>(n=124) | Sign<br>(n=147) | Brochure<br>(n=94) | Naturalist<br>(n=62) | Study<br>Average |
| Natural<br>Science   | 15                 | 16              | 12                 | 15                   | 15               |
| Other<br>Science   | 17                 | 19              | 12                 | 19                   | 17               |
| Engineering  | 10                 | 5               | 5                  | 6                    | 7                |
| Education  | 13                 | 13              | 19                 | 13                   | 14               |
| Liberal<br>Arts  | 23                 | 29              | 29                 | 18                   | 26               |
| Business   | 16                 | 14              | 17                 | 24                   | 17               |
| Technical/<br>Other  | 6                  | 4               | 6                  | 5                    | 5                |

| Table V.5 - Percent of Study Group Participants Living Within Ten Miles of a Wetland or Not. |                 |              |                  |                    |               |
|--|-----------------|--------------|------------------|--------------------|---------------|
| Within ten miles?  | Control (n=263) | Sign (n=328) | Brochure (n=181) | Naturalist (n=124) | Study Average |
| Yes  | 54              | 58           | 61               | 55                 | 57            |
| No   | 37              | 38           | 31               | 39                 | 36            |
| Not sure   | 10              | 5            | 8                | 6                  | 7             |

| Table V.6 - Percent of Study Group Participants in Categories of Number of People in their Party. |                 |              |                  |               |
|---|-----------------|--------------|------------------|---------------|
| Number in party   | Control (n=264) | Sign (n=329) | Brochure (n=180) | Study Average |
| 1   | 3               | 6            | 4                | 5             |
| 2   | 43              | 48           | 50.0             | 47            |
| 3   | 15              | 15           | 14               | 15            |
| 4   | 21              | 19           | 16               | 18            |
| 5 or more   | 17              | 12           | 16               | 16            |

| Table V.7 - Percent of Study Group Participants in Categories of Number of People Under the Age of Fifteen in their Party. |                 |              |                  |               |
|--|-----------------|--------------|------------------|---------------|
| Number under age fifteen   | Control (n=264) | Sign (n=329) | Brochure (n=180) | Study Average |
| 0  | 60              | 63           | 63               | 62            |
| 1  | 13              | 13           | 11               | 13            |
| 2  | 17              | 15           | 17               | 16            |
| 3 or more  | 10              | 9            | 10               | 9             |

## Appendix VI

Visitor Population on the Hatfield Marine Science  
Center Estuary Trail.  
November 1991 through May 1993

| Time Period                              | Visitor Population<br>on the Trail |
|--|------------------------------------|
| November 1 to 30, 1991                   | 2338                               |
| December 2 to 31                         | 1999                               |
| January 1 to 31, 1992                    | 2178                               |
| February 1 to 29                         | 2554                               |
| March 1 to 29                            | 5575                               |
| March 30 to April 30                     | 5090                               |
| May 1 to 31                              | 7265                               |
| June 1 to 28                             | 4060                               |
| June 29 to July 29                       | 9060                               |
| August 2 to September 1                  | 6814                               |
| September 2 to 27                        | 3324                               |
| September 28 to October 25               | 3081                               |
| October 26 to November 29                | 2422                               |
| November 30 to December 27               | 724                                |
| December 28, 1992 to<br>January 31, 1993 | 1590                               |
| February 1 to 28                         | 2041                               |
| March 1 to 28                            | 3475                               |
| March 29 to April 25                     | 2855                               |
| April 26 to May 30                       | 6002                               |



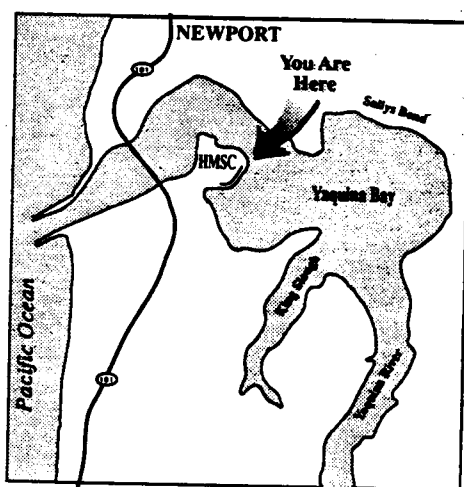
Appendix VII  
Hatfield Marine Science Center  
Estuary Trail Brochure  
(revised)

**The  
Yaquina  
Estuary  
and its  
Inhabitants.**



The Hatfield Marine Science Center welcomes you to the Yaquina estuary. Here you are invited to take a one mile stroll, to the end of this trail and back.

Look for the numbered stops. Each corresponds to pages in this booklet that offer information on the estuary.



## What is an estuary?

1

### A place where fresh and salt water meet.

An estuary is a place where fresh and salt water meet. Here in Yaquina Bay high tide brings salt water from the ocean to mix with fresh water flowing down the Yaquina River.

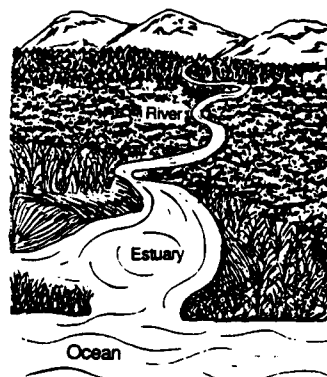
### A place that provides shelter.

A haven from ocean waves and turbulent river currents, an estuary is a relatively calm environment that can shelter organisms from powerful water movements.

### A place of change.

Salinity, the amount of salt in the water, changes daily in the estuary. During high tide salinity increases, as the tide recedes it decreases.

Daily tides also bring changes in water level. While some areas are always under water, tidal fluctuations leave many habitats exposed to air for varying lengths of time. These are called intertidal areas

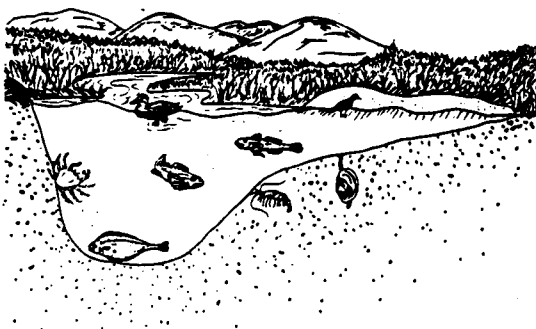


2

## Who lives in the estuary?

Shorebirds, waterfowl, clams, shrimp, and fish, are some of the many animals that live in the Yaquina estuary.

Animals and plants that live in the estuary are uniquely adapted, or suited, to life in an environment where water level and salinity change with every tide. Some fish adapt by leaving the upper estuary when salinity is low. Clams close their shells tightly at low tide protecting themselves from drying out.



### What is Detritus?

Although animals eat some of the plants growing in

the estuary, most vegetation eventually dies. Bacteria then break down plant matter into bits and pieces and tides and currents carry it about. This is detritus.

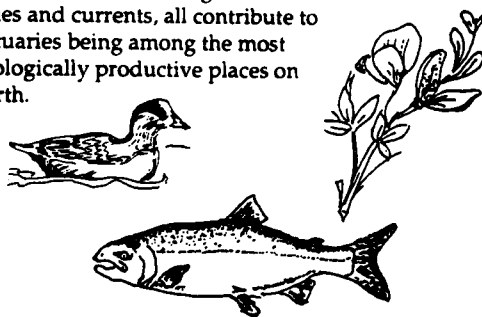
Detritus also comes from the Yaquina River. As the river flows into the estuary it slows and begins to drop its load of decaying plant and animal matter. This "rain" of organic material is another source of detritus for the estuary.

### Detritus and the food web.

Detritus is a nutritious food for numerous animals such as clams, worms, and young fish. They, in turn, may be eaten by larger fish, seals, or birds in a complex food web that also includes humans.

### How Productive is the Estuary?

The combination of a large supply of nutrients from the river and the ocean, an abundance of detritus, and the constant mixing that occurs due to tides and currents, all contribute to estuaries being among the most biologically productive places on earth.



### 3 How many different habitats are found in the estuary?

Within an estuary there are four habitats; open water, eelgrass beds, tideflats, and salt marshes. A fifth habitat, the uplands, is the land adjacent to the estuary.

#### Open Water Habitat.

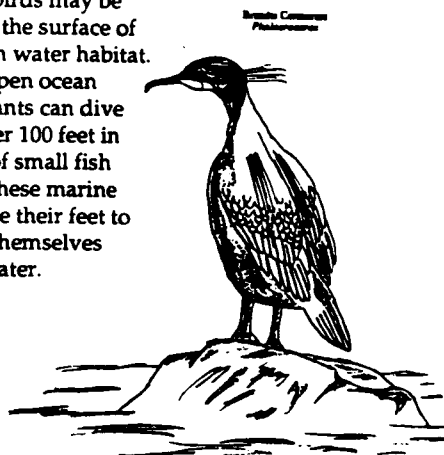
Never exposed by the tides, the open water is a deepwater habitat. **Fish, seals, sea lions,** and occasionally **whales** move into this habitat from the ocean, seeking food and shelter from predators.



Chinook  
*Oncorhynchus tshawytscha*

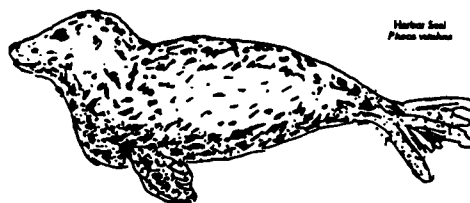
Chinook and Coho salmon migrate through the open water habitat and into the Yaquina River and its tributaries to spawn. Juveniles return through the open water habitat to salt marsh creeks in the estuary, there they feed and seek shelter from predators. Young salmon may spend up to a few months in the estuary before moving to the ocean.

Cormorants and other diving birds may be seen on the surface of the open water habitat. In the open ocean cormorants can dive well over 100 feet in search of small fish prey. These marine birds use their feet to propel themselves underwater.



Double-crested  
Cormorant  
*Phalacrocorax auritus*

Harbor seals are often seen in estuaries, either resting along the shore or feeding in the open water habitat. Food for this marine mammal can include salmon, herring, and starry flounder.



Harbor Seal  
*Phoca vitulina*

## Eelgrass Bed Habitat.

4



Adjacent to the open water habitat are the eelgrass beds, a wetland habitat that is exposed only by the lowest tides. Eelgrass forms dense underwater meadows; nurseries that provide shelter and food to many juvenile fish and shellfish.

### Who lives in the eelgrass beds?

Dungeness crabs hatch in the ocean and move to shallow water and estuaries at about 3 months. Feeding on clams and small crustaceans, many juvenile crabs hide from predators in dense eelgrass beds.



Dungeness Crab  
*Cancer magister*

Pacific herring enter the Yaquina estuary in February to spawn. Females produce up to 30,000 sticky eggs that adhere to eelgrass, seaweed and rocks. The eggs hatch in 10 days and the estuary becomes a nursery for the young herring who remain there through the fall.



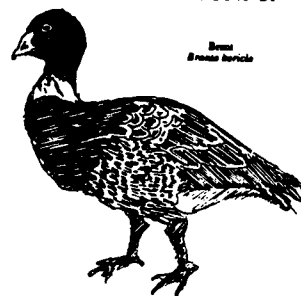
Pacific Herring  
*Clupea pallasii*

Bay pipefish are well camouflaged in eelgrass beds where they spend much of their lives. The breeding season for pipefish begins in February, and it is the male that carries the eggs in a brood pouch on his underside.



Bay Pipefish  
*Syngnathus abaster*

The Brant is a small goose that winters in the Yaquina estuary. Eelgrass constitutes about 80% of the diet of these birds. Dredging and other human activities have reduced the amount of eelgrass in west coast estuaries. Healthy Brant populations depend on preserving remaining eelgrass beds.



Brant  
*Branta bernicla*

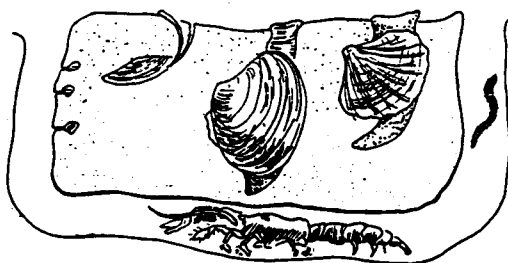
## Tideflat Habitat.

5

At low tide you will see the tideflats. Appearing barren from a distance, a close up view reveals the myriad of organisms that make a home in this wet-land habitat.

### Who lives in the tideflat?

The ghost shrimp lives in a burrow it digs in the sediment. The ghost shrimp is a deposit feeder; it swallows sediments and digests the thick coat of bacteria living on mud particles. Worms, pea crabs and clams take advantage of the shrimp's hard work

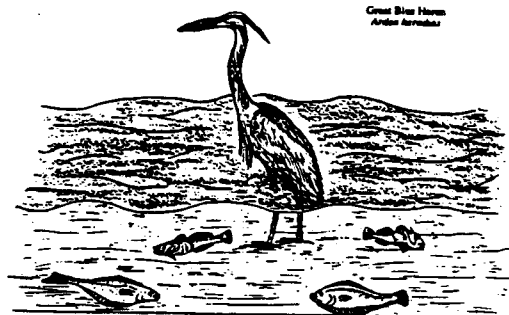


Ghost Shrimp  
*Callinectes californiensis*

and live in the burrow. The free-loaders feed on the shrimp's leftovers or filter plankton and detritus from the water.

**Clams.** Many of Oregon's clam species live in the estuary. Extending their fleshy siphons to the sur-

face, most clams feed by filtering plankton and detritus when the tide is high. The tideflat is home to **gapers**, **littlenecks**, and **softshell clams**, among others.



Great Blue Heron  
*Ardea herodias*

While clams come in many sizes, we can determine the age of some by counting growth rings on the shell, much the same as counting rings on a tree.

**Fish and birds.** When the tide is high fish such as **starry flounder** and **sanddabs** migrate over the tideflats from nearby habitats to feed. The opportunity for dinner is not lost on **Great Blue Herons**, large birds that can be seen wading on the tideflats in search of fish. The successful heron pierces its prey with the tip of its long sharp bill.

In the past, vast areas of mudflat habitat were covered by the material from dredging activities. The remaining mudflats are under pressure for development in many estuaries around the globe.

## Birds of the Open Water, Eelgrass Bed, and Tideflat Habitats.

6

Millions of birds migrate annually along the Pacific coast, flying from Arctic breeding grounds to wintering areas in the south. Calm protected estuaries and other wetlands provide vital rest stops, and the highly productive estuaries supply many birds with the food they need to spend the winter or continue their journey.



**Shorebirds.** At low tide, look over the tideflats for shorebirds such as sandpipers, dunlin, and whimbrels.

A sandpiper uses its short bill to collect animals on or just below the surface while the whimbrel uses its long curved bill to probe deep into the mud for shrimp and worms.

Western Sandpiper  
*Frederick mairi*



Whimbrel  
*Numenius phaeopus*



Most of the aquatic birds in the Yaquina estuary are seasonal visitors, either spring and fall migrants or individuals spending the winter.

**Waterfowl.** While swans are rare in the Yaquina estuary, ducks and geese commonly occur from September through May and can be seen on the surface of any submerged habitat in the estuary.



American Widgeon  
*Mareca americana*

The American widgeon is a dabbling duck. A dabbler feeds by tipping forward and submerging its head and neck to reach for underwater food, generally plants and small invertebrates.

**Lesser scaups** are diving ducks, they propel themselves underwater with large feet attached to short legs situated far back on their body. The bills of lesser scaups are specialized for straining small crustaceans and other invertebrates from the water.

Lesser Scaup  
*Anas affinis*



## Upland Habitat.

7

A habitat that is next to the estuary, the uplands begin where the highest high tide of the year stops. For most of this trail you are walking through the upland habitat.

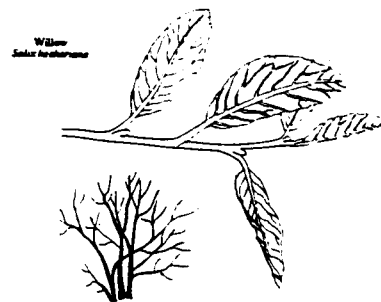


While spring and summer are the best time to see flowers along the estuary trail, many of the perennial plants are easily identified throughout the year.

Yarrow can be seen all along the trail blooming from June through September. Native Americans used this aromatic plant as a tea and strong solutions of yarrow were used medicinally.



Bush lupine, introduced from northern California, has bacteria in its roots that convert nitrogen from the atmosphere to a form the plant can use. A member of the pea family, lupine does well in the low nitrogen soils of the Pacific Northwest.



Like most upland plants, willow cannot tolerate soil that is high in salt. The bark of this tree was chewed by Native Americans to relieve headaches. Today salicylic acid, a primary component in modern day aspirin, is extracted from the willow.

Some of the plants here are native, having arrived before the first Euroamericans, yet many are not. Introductions such as European beach grass, were planted to stabilize dunes or shifting sand. Others like Scotch broom were planted as ornamentals. Non-native plants often have the ability to outcompete and displace the native ones in an area, a process that can eventually lead to a local decrease in species diversity.





## Salt Marsh Habitat.

8



The salt marsh is a wetland habitat that lies in protected areas along the fringes of the estuary, above the tideflats and below the uplands.

Salt marshes are created by the first plants that establish themselves on high points on the tideflat. The first to take hold are **pickleweed**, **salt grass** and **arrowgrass**. As these colonizers begin to grow, they slow down currents and trap sediment, building the marsh up and out towards the bay.

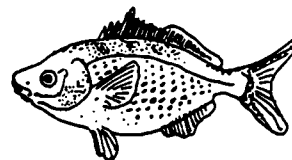
Arrowgrass  
*Typha latifolia*



### Who lives in the saltmarsh?

**Fish.** Because daily tides expose the salt marsh to the air, aquatic animals are not common. Those that do occur usually migrate in and out with the tides.

**Pacific staghorn sculpin, shiner perch, and juvenile salmon** swim up into salt marsh creeks and pools at high tide to feed and hide from predators.



Shiner Perch  
*Cymatogaster aggregata*

**Shorebirds** rest in the saltmarsh and the grassy shore when high tide covers the mudflats. They feed on invertebrates in the low marsh.

**Kingfishers** are diving birds that can be seen feeding on small fish in salt marsh creeks at high tide.

### Marsh plant adaptations.

Salt water is toxic to most flowering plants, causing fresh water to move out of their cells and dissolved salts to move in. Those plants that survive in the salt marsh do so only with special adaptations. One common adaptation is succulence, dealing with high salinity by dilution. A bite into the fleshy stem of the **pickleweed** will reveal its unique adaptation. This plant actually stores salty water in its stems.



Pickleweed  
*Sarcocornia virginica*

## The estuary.

9

An estuary is a place where fresh and salt water meet. It is a calm protected environment where animals seek shelter and food. An estuary is also a place of change. Organisms that live there must be capable of adapting to the ever-changing conditions.

Some inhabitants are well suited to year round life within one of the four habitats of the estuary. Others spend only a portion of their lives there, using the estuary as a nursery, migration stopover, or place to feed.

Many of Oregon's estuarine habitats have been altered due to human activities. Few natural salt marshes remain in the Yaquina estuary, and pressure to continue dredging and filling threatens many estuaries in Oregon, and around the world. Preserving the habitats that remain in estuaries is vital for the survival of many organisms that depend on these highly productive environments.

